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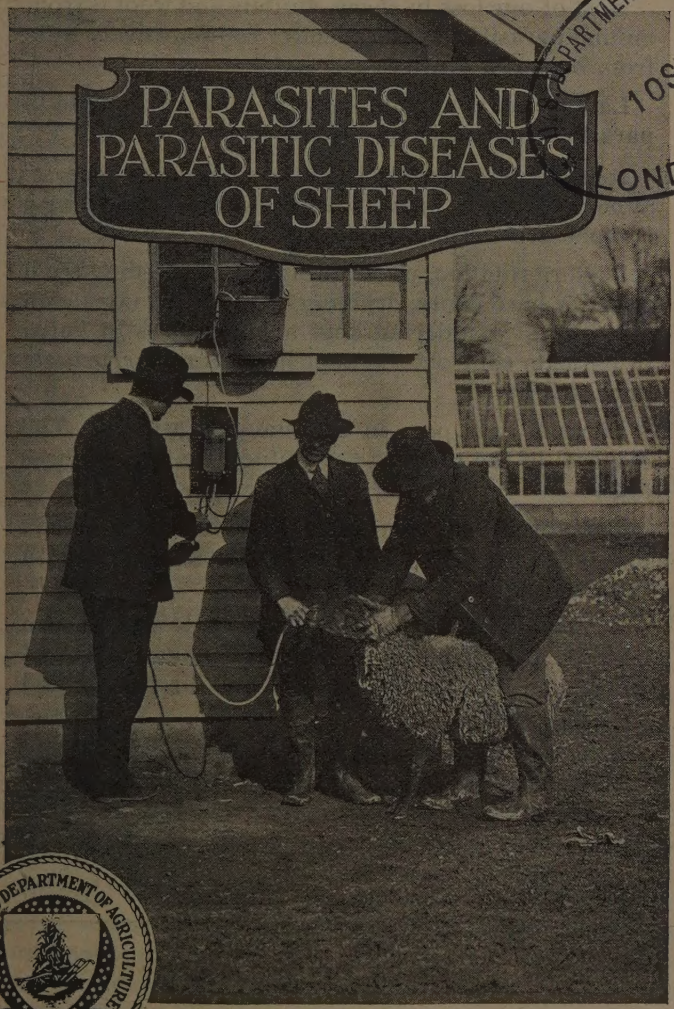
PARASITES AND PARASITIC DISEASES OF SHEEP



UNITED STATES DEPARTMENT OF AGRICULTURE
1862 AGRICULTURE IS THE MOST HEALTFUL AND USEFUL OF ALL HUMAN OCCUPATIONS 1889
FOUNDATION OF MANUFACTURES

SHEEP PROBABLY SUFFER more from parasites than do any other kind of livestock.

Most of our loss in sheep, mutton, and wool is from animal parasites, as sheep suffer comparatively little from bacterial diseases.

Lambs and young animals are most susceptible to parasites and suffer most from them.

It is the sheepman's business to *prevent* disease. When disease is present it is advisable to call in a competent veterinarian.

Pasture rotation, use of forage crops, feeding from racks or bare floors, draining or filling swamps, and restraint of wandering dogs are measures of value in parasite control. *Permanent pastures perpetuate parasites!*

Parasite eggs pass in the manure, usually. The disposal of the manure determines the fate of these eggs.

Parasitized animals usually do not have fever; they are unthrifty. This unthriftiness may have a fatal termination.

Act promptly to ascertain the trouble when sheep become unthrifty. A post-mortem examination of one of the sick animals may disclose the trouble and save the others.

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Washington, D. C. Issued April, 1923

PARASITES AND PARASITIC DISEASES OF SHEEP.

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CONTENTS.

	Page.
Susceptibility of sheep to parasitic diseases	3
Important preventive measures	4
External parasites	5
Lice	5
The sheep tick	8
Sheep-scab mite	10
Other external parasites	13
Internal parasites	16
Arthropods	17
Grub in the head	17
Tapeworms	20
The moniezias	20
The fringed tapeworm	22
Bladderworms	24
The thin-necked bladderworm	24
Sheep measles	26
Internal parasites—Continued.	
Bladderworms—Continued.	
The gid parasite	27
The hydatid	31
Flukes	33
The common liver fluke	33
The large liver fluke	36
Roundworms	37
The stomach worm	38
The nodular worm	42
The sheep hookworm	45
The thread-necked strongyles	47
The whipworm	48
The thread lungworm	50
The hair lungworm	51
Other internal parasites	53

SUSCEPTIBILITY OF SHEEP TO PARASITIC DISEASES.

SHEEP are very liable to attack by parasites, probably suffering more severely from this cause than any other kind of livestock. The importance of parasites and parasitic diseases of sheep is the more evident because of the fact that sheep are but little subject to serious bacterial plagues or virus diseases. In this country sheep rarely have tuberculosis, which is one of the serious conditions in cattle and swine, and among sheep there is nothing comparable to the devastating outbreaks of hog cholera among swine. Occasionally a virulent strain of the bacillus producing lip-and-leg ulcer will spread under favorable conditions and necessitate the treatment of entire flocks, or individual sheep will die of pneumonia or other bacterial diseases, but the steady loss of sheep, mutton, and wool from disease in this country is due mostly to parasites.

The damage from parasites is greatest as a rule among lambs and young animals. The young tissues seem less resistant and more intolerant of injury and the more sensitive nervous system breaks down more quickly under the influence of parasitic injury and poisoning from the excretions and secretions of parasites. It also seems to be fairly well established that in general young animals

are more easily infected by parasites than older ones, although very old sheep sometimes appear to acquire an increased susceptibility to infection. Hence it is important in undertaking to prevent infestation with parasites to pay especial attention to the care and handling of lambs and yearlings.

IMPORTANT PREVENTIVE MEASURES.

The use of measures intended to prevent sheep from becoming infested with parasites is especially the function of the sheepman. When sheep become diseased, the niceties of diagnosis and the administration of drugs are well within the province of the veterinarian. Errors in diagnosis by unskilled persons waste valuable time and lead to useless or injurious measures. Drugs intended to kill parasites are from the nature of things usually very potent, and are commonly poisonous substances capable of doing much damage in the hands of unskilled or careless persons; therefore, it is usually advisable to secure the services of a competent veterinarian whenever there is an outbreak of disease and a good veterinarian is available. In places where there are no qualified veterinarians available, the farmer or stockman must use his own judgment in determining whether he can recognize the trouble and administer the remedy.

One of the most important preventive measures in keeping flocks free from parasites is based on the fact that many of the sheep parasites live in the digestive tract of the sheep or in organs in communication with the digestive tract, so that the eggs or young worms pass out in the manure and thus infect the pastures. The fact that sheep manure carries worm infestation is the basis of such preventive measures as pasture rotation, rotation of different kinds of stock on the same pasture, feeding from racks or board floors, use of bare lots for nursing lambs, etc.

Another important preventive measure is based on the fact that many parasites which do not get back to the sheep from a pasture infected with sheep manure are carried back to the sheep by dogs. The fact that the dog which feeds on uncooked sheep meat or viscera may become infested with worms that produce eggs which pass out on to the pastures and may then infect the sheep, is the reason for keeping sheep dogs and other dogs on the farm free from worms and related parasites and for insisting that stray dogs must not wander over pastures and fields under penalty of being shot. Another preventive measure is based on the fact that diseases like scab are transmitted by contact with infected animals and places, and clean flocks must be protected from unsafe contacts.

In a general way, the presence of parasites may be suspected as the cause of disease where there is little or no fever, the animals losing

condition and becoming thin and commonly having a diarrhea or being constipated. Other features may be associated with certain parasites. Bloodsucking parasites produce anemia, the blood becoming thin and pale as a result of having too few red blood corpuscles for the amount of serum present. Often there is associated with this an edema, in which fluid accumulates in the pendant or lower portions of the body; this is especially prominent in stomach-worm infestation in sheep, the fluid accumulating under the lower jaw and giving rise to the so-called "bottle jaw."

In this connection, the advisability of finding out promptly the cause of the trouble when sheep become diseased should be emphasized. Curtice has stated the case as follows:

> The sheep owner who discovers weakness among his lambs should not wait until one of them dies before he endeavors to make a diagnosis, but should undertake to diagnose the disease in the earlier stages by sacrificing one or more of the worst affected, and thus gain time in treating and preventing the extension of the disease. By waiting for the disease to develop he allows the lambs to grow poorer and weaker, and when action is finally undertaken it is upon patients which are, in many cases, already too weak to stand vigorous treatment and which in no way profit by preventive measures as they should.

EXTERNAL PARASITES.

External parasites are those which live on the exterior of another animal called the host animal, that is, on the skin or in the layers of the skin or in the hair follicles. Internal parasites are those which live in the body tissues or cavities of the animal that serves as a host.

The external parasites of sheep are all arthropods, or animals having 6 or more legs, some of them being insects, which have 6 legs in the adult stage, others, such as mites and ticks, being more closely related to the spiders and possessing 8 legs in the adult stage. Some of these parasites spend their lives on the sheep; this is true of the scab mites and the lice. These are the important forms. Others, such as various kinds of biting flies, attack sheep occasionally but spend much of their lives off the sheep.

LICE.[1]

Location.—Lice live on the skin of sheep, crawling about on the wool or hair from place to place and clinging to the wool fibers or hairs in feeding. The sucking body louse (*Hæmatopinus ovillus*) is commonly found in colonies on various parts of the body, including the face. The foot louse (*Linognathus pedalis*) is usually found on the lower portions of the legs, below the true wool and in the short, coarse hair. The biting louse (*Trichodectes ovis*) occurs on various parts of the body.

[1] *Hæmatopinus ovillus, Linognathus pedalis, Trichodectes ovis* (=*Tr. sphærocephalus*).

Appearance.—The sucking body louse has a head somewhat longer than the thorax (fig. 1). The abdominal segments bear two rows of long hairs. The male is 2.1 millimeters (about one-twelfth of an inch) long and the female is 2.8 mm. (about one-tenth of an inch) long. There is an inconspicuous eye on each side of the head. The wool in the region attacked by this louse is usually discolored and contains numerous brown particles, the fecal deposits of the lice.

FIG. 1.—Sucking body louse (*Hæmatopinus ovillus*). Female, back view. Highly magnified. (From Neumann, 1907.)

The foot louse has a short head, as wide as it is long, which merges into the thorax, with reddish oblique bands on each side (fig. 2). No eyes are present. The abdominal segments bear two rows of hairs, of which those at the lateral margin are longer than the others. The female is 2.2 mm. (about one-twelfth of an inch) long and 1 mm. (one-twenty-fifth of an inch) wide; the male is broader and flatter. This is a sucking louse like the preceding species.

The biting louse has a head that is wider than long, with a broad, round anterior end (fig. 3). The abdominal segments show a median dark line and have only a single row of hairs. The male is 1.4 mm. (about one-twentieth of an inch) long and the female is 1.6 mm. long.

Life history.—The eggs of the various species of sheep lice are attached to the hair or wool in the sites customarily infested by the adult lice. The eggs of the sucking lice are said to hatch in 10 to 18 days; those of the biting lice in 5 to 8 days ordinarily, or 10 days in cold weather. Available evidence indicates that the young lice become mature and begin laying eggs in the course of about two weeks after hatching. The sucking lice, as the name implies, are bloodsuckers. The biting lice feed on the epithelial scales and other material on the surface of the skin. Lice usually cause little trouble in summer, but become more numerous and annoying in winter.

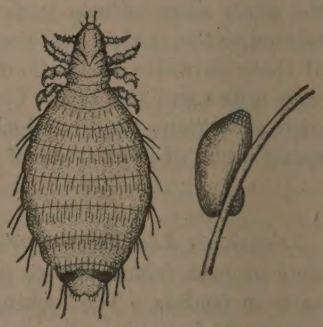

FIG. 2.—Sheep foot louse (*Linognathus pedalis*). Adult female and egg, enlarged. (From Osborn, 1896.)

Distribution.—Biting lice are rather common in the United States. The sucking body louse is fairly common on sheep in the Southwest. The foot louse has been found on sheep in various parts of the country.

Symptoms and lesions.—Lice, whether biting lice or sucking lice, cause itching and irritation. This of itself interferes with nutrition, and affected animals fail to fatten or keep in condition as they should. Moreover, the itching leads to scratching, with a resultant loss of wool, and this scratching adds more time lost from feeding to that lost from discomfort. Scratching may also cause cuts and bruises. The loss of nervous energy and the interference with feeding and nutrition tend to stunt the growth of young animals, interfere with the fattening of the entire flock, and predispose to other diseases by lowering the vitality. Actual lesions in the form of sores are caused where numerous biting lice cluster. The sucking lice abstract blood and lymph in considerable quantities where the lice are numerous. Finally, the excreta of the lice soil the wool, sometimes to a considerable extent; this is particularly true of the sucking body louse.

Lice are readily found on infested animals by examining them carefully, preferably in direct sunlight.

FIG. 3.—Sheep louse (*Trichodectes ovis*). Adult female, enlarged. (After Neumann, 1892.)

Treatment.—Where sheep are infested with biting lice only, sodium fluorid may be applied in the form of a powder to get rid of them, a single application sufficing for this purpose. The powder is rubbed into the skin at a number of places so as to insure a good distribution. It is of no value against sucking lice. Sodium fluorid should not be applied to mucous membranes, such as those of the mouth and anus.

For sucking lice it is necessary to use a contact poison, and these poisons are also satisfactory for biting lice. In cold weather, where dipping is inadvisable, insect powders, composed largely of pyrethrum and naphthalene, may be used as a control measure and will serve to control the lice, but are not satisfactory in eradicating them.

For dipping, the substances which have been found effective in field tests are coal-tar creosote, cresol, arsenical dip, and 0.07 per cent nicotin solution with 2 per cent flowers of sulphur. To eradicate lice it is usually necessary to dip at least twice, with an interval of 14 to 16 days between dippings, in order to kill the lice that hatch out after dipping, since these dips can not be depended upon to kill all the eggs or "nits." Spraying is generally unsatisfactory as a method of applying dips to sheep, as it is too difficult to wet the wool.

Sheep should be handled carefully, not roughly. Dip the bucks, ewes, and lambs separately. The sheep should be fed and watered from 3 to 6 hours before dipping, in order that they may not be hungry or thirsty and yet not gorged with food. In hot weather they should be cooled off before dipping, and when the nights are cold they should be dipped in time to dry off before night. Ten days should elapse after shearing before dipping, in order that cuts may heal, especially when arsenical dips are used. Because of their extremely poisonous nature it is usually inadvisable to use arsenical dips in treating sheep.

Prevention.—To prevent infestation with lice it is essential that contact with lousy animals be prevented and that animals free from lice be kept out of sheds, pens, inclosures, or pastures where lousy stock has been present within three weeks. After the first dipping, sheep should be put on clean pastures or held in clean inclosures to allow time for any eggs to hatch and the lice to die, or else the sheds and lots should be thoroughly cleaned out and disinfected before using them. For this sort of disinfection the coal-tar dips in double the strength used for dipping are satisfactory.

THE SHEEP TICK.[2]

Location.—The sheep tick occurs in the wool and on the skin.

Appearance.—The sheep tick is not really a tick, but is a kind of wingless fly (fig. 4). It has 6 legs, whereas the full-grown true ticks have 8 legs. The mouth parts are very similar to those of other flies. These insects are reddish or gray-brown in color, and are about a quarter of an inch long on an average, and may therefore be easily distinguished from the lice. They are distinctly divided into head, thorax, and abdomen, which distinguishes them from the true ticks, which are occasionally found on sheep, as these true ticks have the thorax and abdomen fused. with the head not conspicuously distinct.

Life history.—The egg of the sheep tick is not laid as such, but is retained in the body of the female until it develops into a larva or pupa, which occurs in about seven days. The pupa is then deposited by the tick and is attached to the wool of the sheep by a gluelike substance. When deposited it is covered with a soft, white membrane, which becomes brown and hard in about 12 hours. The pupæ of the sheep tick are commonly called eggs. The young ticks emerge from the pupal stage in 19 to 24 days, the shorter time being in warm weather and the longer in cold weather. The tick is almost full-grown when it leaves the pupal case and it becomes mature in 3 to 4 days. After copulation the female may deposit its first pupa in 8 to 10 days.

[2] *Melophagus ovinus*. For additional information see Farmers' Bulletin 798 on "The Sheep Tick."

Distribution.—Sheep ticks are widely distributed over the world and are common in the United States on both farms and ranges. Where dipping of range sheep for scab has been practiced it has kept down the sheep tick, but where it has ceased sheep ticks have become very prevalent. They are most common on coarse-wool and medium-wool sheep, and prefer the neck, breast, shoulders, belly, and thighs.

Symptoms and lesions.—The damage done by the sheep tick is of two kinds. It is a bloodsucker, thus causing great irritation, loss of blood, interference with feeding, and consequently poor nutrition and reduced vitality. It lives in the wool and lowers the value of the wool by soiling it with the excreta and with the pupal cases. The loss caused is in addition to the wool deterioration which results from the injury to the sheep itself. The ticks may be easily found on parting the wool. Their presence may be suspected when sheep bite, scratch, or rub, and show a ragged fleece as a result.

FIG. 4.—Sheep tick (*Melophagus ovinus*). Engorged female, enlarged. (From Imes, 1917.)

Treatment.—The treatment for ticks is dipping. The coal-tar creosote, cresol, nicotin, and the lime-sulphur-arsenic dips are all satisfactory, but dips containing arsenic are not desirable for sheep. Dip twice at a 24- to 28-day interval.

Prevention.—All places which have been occupied by ticky sheep should be regarded as dangerous from this standpoint for a period of two months, as the pupæ may retain their vitality under certain conditions for almost this length of time. Usually pupæ remain in the wool, but wool containing pupæ may be rubbed off or pulled off and young ticks hatching from such pupæ may afterwards get on sheep. If inclosures are to be used for clean sheep within this period they should be thoroughly cleaned and the litter and manure disposed of in such a way that sheep can not come into contact with them until after the lapse of the 60-day period. A strong solution

of coal-tar dip should also be used, but this can not be depended on to kill the pupæ, though it is useful in killing the ticks that might escape a cleaning process. To disinfect stone or wire-fence corrals, brush or straw may be scattered over the surface of the ground and burned. Clean sheep must be kept away from contact with ticky sheep and care must be taken to see that goats or other animals do not convey ticks to the sheep. Even persons may occasionally carry ticks for a short time in their clothing, and this must be kept in mind at shearing time and whenever there is danger of infection from persons who travel from one flock of sheep to another.

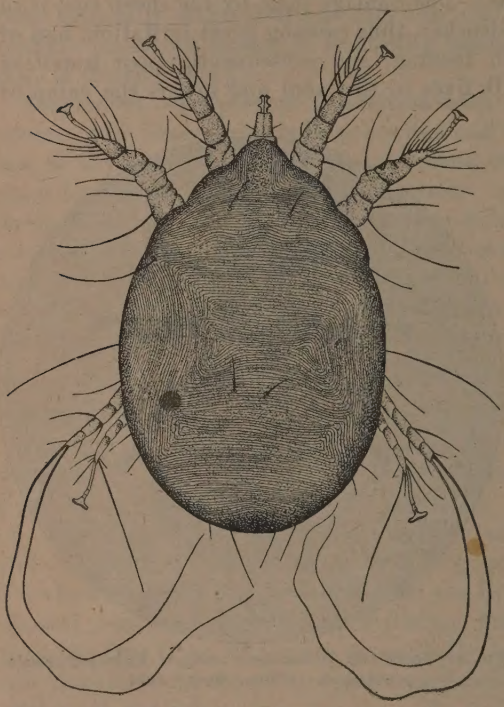

FIG. 5.—Sheep-scab mite (*Psoroptes communis ovis*). Female. Back view, greatly enlarged. (After Salmon and Stiles, 1898.)

SHEEP-SCAB MITE.[3]

Location.—On the skin.

Appearance.—These parasites are very small animals, commonly called scab mites (fig. 5). The male is only 0.5 mm. (one-fiftieth of an inch) long and the female 0.625 mm. (one-fortieth of an inch), but they may be seen with the naked eye as small white objects, especially when placed on a dark background. It is easier to see them when they are warmed, by sunlight or otherwise, on such a background, as they may then be seen in motion. The full-grown mites have 4 pairs of legs and these legs have long hairs. In the female there is a so-called sucker on a jointed stalk on the tip of the first, second, and fourth pairs of legs, and in the male on the first, second, and third, the fourth pair in the male having a sucker which is not on a jointed stalk.

[3] *Psoroptes communis ovis.* For additional information see Farmers' Bulletin 713 on "Sheep Scab."

Life history.—The female mite usually deposits at least 15 eggs during her life, and may deposit 24. In 3 or 4 days these hatch, the young mites beginning life with only 6 legs. In 7 or 8 days these have become 8-legged mites, which mate and begin depositing eggs in the course of the next 3 or 4 days. One investigator (Gerlach) has estimated that in 90 days this rate of reproduction under favorable circumstances, beginning with a single impregnated female, would produce one and one-half million mites.

Distribution.—Scab was formerly widely distributed over the United States, being the greatest pest that sheepmen had to contend with. Quarantine and eradicative dippings have nearly cleaned it out of the greater part of this country, so that at present

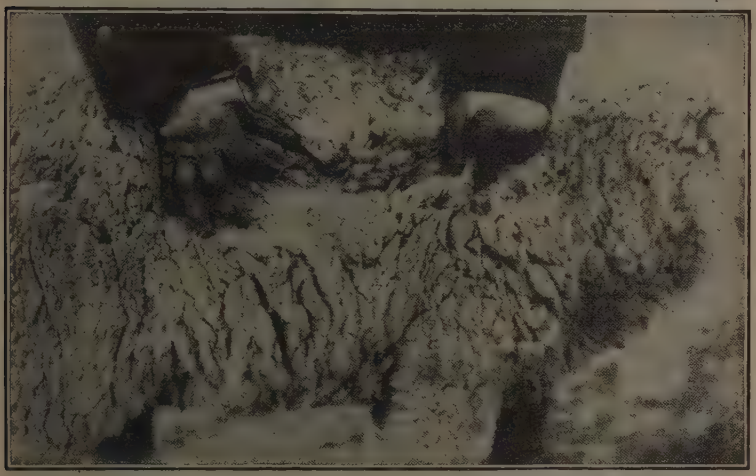

FIG. 6.—Characteristic scab lesion in early stages of the disease. (From Imes, 1916.)

it is largely a matter of cleaning up the relatively small amount that is scattered about, an exceedingly difficult task, however, because of the scattered condition of the infection. The cooperation of individual owners in promptly reporting to local livestock sanitary authorities cases of scab or cases suggestive of scab is highly important in scab eradication.

Symptoms and lesions.—The scab mite pricks the skin and sucks the blood serum. The puncture becomes inflamed, forming a small red spot with a slight exudation of serum. This serum forms the scab, from which the disease takes its name (fig. 6). The watery part of the serum dries out, leaving a small crust for each bite, the total aggregate of these bites leading to the formation of considerable crusts or scabs. At the same time the bite of the mite causes itching, and this in turn leads to scratching, rubbing, and biting,

thereby adding to the initial inflammation and producing a certain amount of hemorrhage as the scabs are rubbed off and sores form. The serum and sores afford lodging and favorable conditions for bacteria and become infected. The skin reacts to the continued inflammation and becomes thickened.

The first symptom noticed as a rule is the itching, manifested by a disposition to rub and scratch. The wool is roughened and broken by the scratching, and this condition suggests the possibility of scab. The sheep become restless and spend considerable time biting and rubbing the affected spots, finally losing the wool off large

FIG. 7.—Scabby buck with entire hind quarters and flank affected. (From Imes, 1916.) (The discolored area is due to dip stain from hand dressing.)

areas and leaving scabby sores (fig. 7). The time and energy spent in trying to alleviate itching is time and energy lost from feeding and growing, and this fact shows itself in the poor condition of scabby sheep. Ultimately many of these sheep will die unless treated and they are always so weakened as readily to fall victims to other diseases.

The diagnosis of this disease is best made by a capable veterinarian, as the disease is too serious to warrant taking any chance on its spread. Itching, loss of wool, and other conditions present in scab may also be shown in the presence of lice, sheep ticks, true ticks, bearded seeds, cactus spines, eczema, wildfire, summer sores,

rain rot, shear cuts, sunburn, and inflammation of the sebaceous glands; the effects of alkali dust may at times be mistaken for scab.

Treatment.—The only satisfactory treatment for scab is dipping. Hand dressing will not suffice and permits the spread of the disease while seeming to cure obviously affected areas. Animals must be dipped twice at intervals of 10 to 14 days, preferably 10, in warm dip. Ewes, bucks, and lambs should be dipped separately. Sheep must be held in the dip not less than two minutes; in the case of animals with advanced cases, especially in the fine-wool sheep, they should be held three to five minutes the first time, unless the crusts and scabs are first broken up and soaked with dip. The lime-sulphur dip and the nicotin-and-sulphur dip are the two dips recognized in official dipping for scabies. Protection from reinfection appears to be afforded for 33 days by the lime-sulphur dip and for 69 days by the nicotin-and-sulphur dip.

Prevention.—Open pasture that has been used by scabby sheep should be regarded as dangerous for a month or two, and buildings are regarded as suspicious for a year or more. Keep sheep away from old bedding grounds and other infected areas. As regards buildings, pens, etc., it is advisable to abandon them, burn them, or else clean and disinfect thoroughly if they are to be used after having had scabby sheep in them. Stray sheep should be looked on with suspicion and goats may carry scab mites for long periods. Care must be used in purchasing sheep from areas where there has been any scab.

OTHER VARIETIES OF SCAB.

Head scab and foot scab in sheep are relatively rare diseases caused by species of mites different from those causing common scab. The same methods of treatment may be used, but head scab may prove more difficult to cure and four or five or more dippings, supplemented by local applications of remedies, may be necessary. In cases of head scab the interval between dippings should be shortened to a week or even to five days.

OTHER EXTERNAL PARASITES.

True ticks occasionally infest sheep, but in this country it is rare to find ticks present on sheep and we are fortunately free from ticks that habitually infest sheep. Among those that do occur on our sheep is the spinose ear tick.[4] This is particularly prevalent in the Southwest. It enters the external canal of the ear and attaches there well below the hair line, sucking blood from the tender skin. The ticks enter the ear as 6-legged seed ticks, become engorged, grub-like larvæ, molt to form the 8-legged nymph, which is covered with numerous small spines, and after months spent in the ear the nymphs

[4] *Otobius mégnini* (*Ornithodoros mégnini*). For additional information see Farmers' Bulletin 980 on "The Spinose Ear Tick and Methods of Treating Infested Animals."

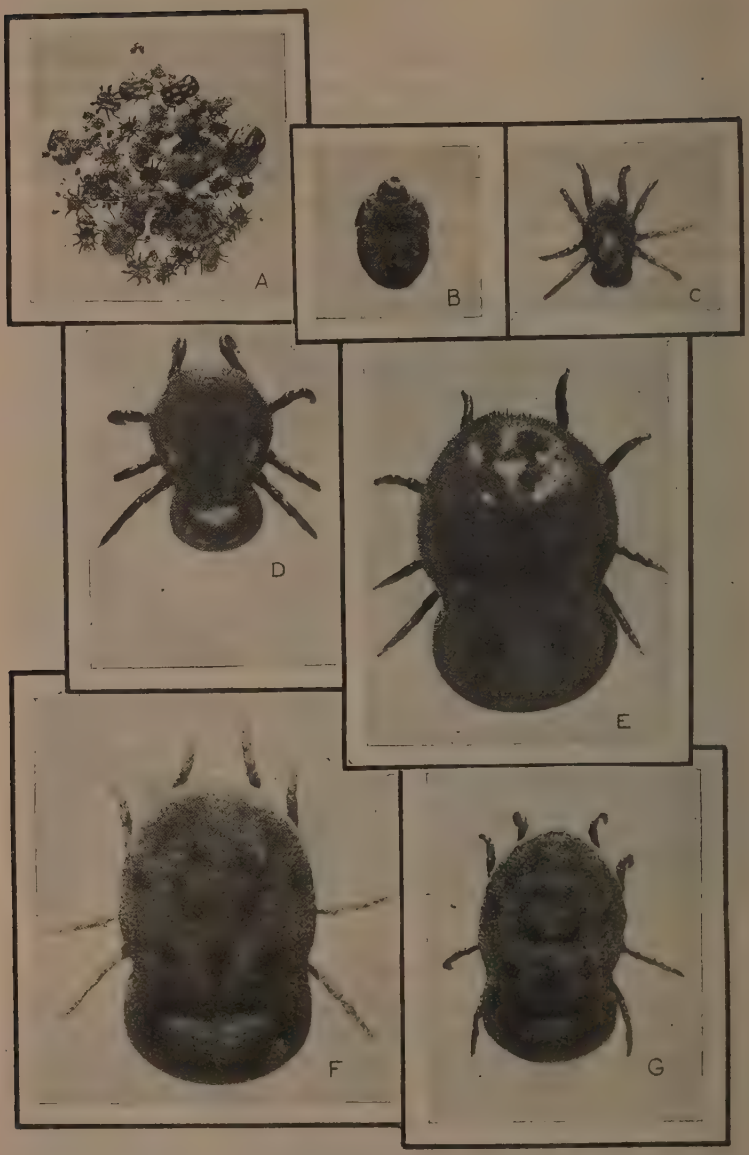

FIG. 8.—The spinose ear tick (*Otobius mégnini*). *A*, ear ticks and débris from ear of cow (about natural size). *B*, engorged larva (magnified five times). *C*, young tick (magnified five times). *D*, partially engorged young tick (magnified five times). *E*, fully engorged young tick (magnified five times) *F*, adult female (magnified five times). *G*, adult male (magnified five times). (From Imes, 1918.)

crawl out, conceal themselves in dry protected places, transform into adult ticks, and mate (fig. 8). The female lays eggs which give rise to the 6-legged seed ticks and these in turn infest new hosts. Infested animals often have the ear canal plugged with wax and the excretions of the ticks. Such animals shake their heads or turn them from side to side. The ticks cause serious injury and occasionally death, especially among horses and cattle. The best treatment is to clean the ear canal with a wire loop, using care not to injure the animal, and inject into the canal a mixture of 2 parts commercial pine tar and 1 part cottonseed oil.

The screw worm[5] is the name commonly given to the maggot of a sort of blowfly especially prevalent in the Southwest. It is especially apt to infest sheep recently sheared, getting into the fresh cuts, and in the same way attacks sheep and other animals that have been recently castrated, dehorned, or otherwise injured by having the skin broken. The fly is larger than the housefly (fig. 9), dark bluish-green in color, with three black stripes on the back between the wings, and with a red or reddish-yellow coloring in the face. It deposits its eggs in carcasses or in wounds, in masses of from 40 to 250 eggs. In wounds these eggs hatch in three hours or less, giving rise to young maggots which burrow into the wound and grow rapidly during a period of 4 or 5 days (fig. 10). They then leave the wound, burrow into the ground and form pupæ. The adult fly emerges from the pupal case in 3 to 14 days, the entire life cycle being 1 to 4 weeks.

FIG. 9.—Screw-worm fly, as seen from above. Much enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

The best treatment for an infested wound is to pour in chloroform, later remove the maggots, wash with a suitable disinfectant, and apply pine tar to prevent fresh attacks. Probing and opening the burrows is regarded as inadvisable. When the wound is severe it is advisable to call in a veterinarian, as there is sometimes serious

[5] *Cochliomyia macellaria* (*Chrysomyia macellaria*). For additional information see Farmers' Bulletin 857 on "Screw-Worms and Other Maggots Affecting Animals."

danger from hemorrhage and infection. Every year numerous animals die from screw-worm infestation.

By way of prevention it is essential that carcasses of animals dying from any cause should be promptly burned or otherwise disposed of so that flies can not breed in them. If they are buried they should be buried in quicklime and the entire carcass should be at least two feet under ground and the soil tightly packed. Shearing cuts and other injuries from accident or operations should be coated with pine tar to prevent flyblow. Flytraps are valuable as control measures.

Sheep-wool maggots belonging to a number of species[6] are somewhat similar in habits to the screw-worm fly. Related flies have become a very serious pest to sheep in Australia. The flies deposit their eggs or young in the wool. Infested sheep are sometimes treated by clipping the wool about infested parts and applying concentrated dip, chloroform, or mixtures of turpentine and tar. It is also advised that lambing should occur as early as possible and shearing be carried on before the warm weather sets in, to reduce the chance of infestation. The wool of sheep, especially those affected with diarrhea, should be kept trimmed about the tail region to prevent flyblow at this place. A practice which has been found of considerable value in Australia consists in spraying the tail region of the sheep with 0.7 per cent solution of arsenious oxid just before lambing time. This can be done quickly and easily, is cheap, and affords considerable protection. The prompt destruction of carcasses is as important in the control of these maggots as it is in the control of the screw worm.

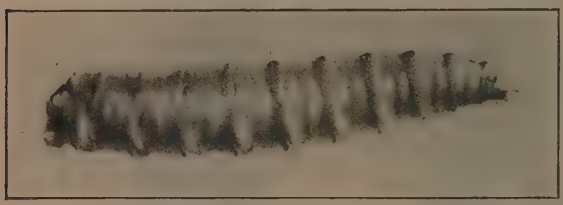

FIG. 10.—Screw-worm maggot, side view. Enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

INTERNAL PARASITES.

The internal parasites include tapeworms, flukes, roundworms, and a few other forms, such as the maggots causing grub in the head, the tongue worm, and the one-celled forms, or Protozoa, these last being microscopic in size and of comparatively little known importance in the United States so far as sheep are concerned.

The following discussion includes the more important of the numerous kinds of internal parasites that infest sheep.

[6] *Phormia regina, Lucilia sericata,* and others.

ARTHROPODS.

The arthropods include certain forms that live during a portion of their life as internal parasites of sheep, though most of the arthropod parasites of sheep are external parasites.

The arthropods are forms which possess 6 or more leglike appendages, such as the insects, which, in a limited sense of the word, include those forms with 6 legs, the spiders and spiderlike forms, which as adults have 8 legs, and other forms having more than 8 legs, some of them having a considerable number.

The life history of the arthropods varies so greatly in the case of different forms that it is hardly possible to give a general statement covering it.

FIG. 11.—Grub in the head (*Œstrus ovis*). Above, normal position; below, grub turned on its back. (From Osborn, 1896, after Riley.)

GRUB IN THE HEAD.[7]

Location.—The grubs occur in the nostrils and in such communicating cavities as the frontal sinus and the maxillary sinuses, cavities in the upper jawbone.

Appearance.—The parasites appear as maggots which at first are less than 2 mm. (one-twelfth of an inch) long. When fully developed in the sheep, they are usually over 2 cm. (four-fifths of an inch) long and 7 mm. (almost one-third of an inch) wide, though the grub may contract or expand to a smaller or greater dimension. There are 11 segments, rather flattened on the ventral (lower) surface and arched on the dorsal (upper) surface. The ventral surface is spiny, the dorsal smooth. At first the grubs are white, later they become yellowish and darker, a band appearing on the dorsal side of the segments and finally becoming black (fig. 11). At the head end are two large hooks and at the tail end are two rounded breathing pores.

FIG. 12.—Adult fly which causes grub in the head (*Œstrus ovis*). Enlarged. (From Bau.)

Life history.—The adult fly (fig. 12), which looks something like an overgrown housefly, is active during the summer, usually in June and July. The female fly deposits a tiny grub on the edge of the sheep's nostril. Sheep usually run when the fly attacks them

[7] *Œstrus ovis.*

or is seen by them, often becoming frantic and holding the nose in the dust or against other sheep. The attack occurs usually during the heat of the day, the fly being quiet in the early morning and late afternoon. The grub migrates up the nostrils by means of its hooks and spines, and may make its way to the communicating cavities. Occasional grubs fail to leave the sinuses in time and become too large to get through the apertures they entered; these die and usually become calcified. The grub in the sinuses feeds and grows until it is ready to leave the sheep. Sometime during the spring or summer, in temperate climates, the grubs leave the sheep and fall to the ground, into which they burrow a short distance. Their skin becomes hard and leathery and they lie quiescent for three weeks to two months, according to conditions of temperature and moisture. Finally the adult flies break out from the leathery envelopes within which they have undergone their transformation from the preceding stage, like a butterfly in a chrysalis, crawl to the surface, and are ready to mate and then to deposit their young.

Distribution.—This parasite appears to be prevalent throughout the United States wherever sheep are kept. It is a common and troublesome pest, especially in the South.

Symptoms and lesions.—As the grub crawls about in the nostrils the hooks and spines set up an irritation which is at first acute with a resultant flow of serum from the nose, resembling a "cold in the head." Presently the nostrils show evidence of bacterial infection, the flow thickens and becomes discolored, presenting the picture called by the sheepmen "snotty nose," a pronounced catarrhal condition. The hooks and spines set up minute hemorrhages, which are visible on post-mortem examination as rows of blackened dots on the mucous lining of the nostrils and sinuses. One result of this irritation and inflammation is a thickening of the mucous membrane, a condition which interferes with its normal function of smell and helps to close the breathing passages, which are already functioning improperly as a result of the thick, catarrhal secretions. As a consequence the sheep experiences difficulty in breathing, which tends to impair its general physical condition. Add to this the fact that the sinuses may become filled with purulent matter and that the toxins from the purulent matter here and elsewhere are constantly absorbed and there is evidently present a condition which must weaken an animal. Furthermore, the irritation due to the wandering of these spiny grubs over the sensitive mucous membrane of the nostrils prevents the sheep from resting or devoting its full time and energy to feeding and growing.

Though the characteristic symptom of grub in the head is the profuse discharge from the nose, the sheep show other evidences of

the infection. They sneeze frequently and often show symptoms of difficult breathing. The eyes become inflamed, as would be expected in connection with an inflammation of the nostrils, the head is often carried low or may be moved about in a peculiar manner as though the sheep were trying to rid themselves of an obstruction in the head, the appetite is diminished, or at least the sheep eat less owing to distraction from pain and difficult breathing, and in severe cases the animals may have convulsions and ultimately die.

Treatment.—The treatment for this condition is not very satisfactory and dependence should be placed on preventive measures, which are, fortunately, of a comparatively simple sort and easily applied. One of the measures which has been advocated in the way of treatment is to put the sheep in an inclosure on hard ground or on a floor of some sort which has been sprinkled with lime, and to mill them around so as to stir up the lime and cause violent sneezing, in the hope of expelling the grubs in this manner. This may remove some grubs from their position in the nostrils, but it can have no effect on those in the sinuses and will by no means remove all those in the nostrils. Attempts have been made to kill or remove grubs by putting the sheep in a room with burning sulphur, some person remaining there as long as possible to test the strength of the fumes. This is dangerous to the sheep and the operator and can not be recommended, especially since it is not very successful. In the case of particularly valuable animals which are seriously affected, the sinuses may be opened with a trephine and the grubs extracted with forceps. Sheep tolerate the operation well enough, but the operation is one that is suitable only for trained and skilled operators and should be done by a competent veterinarian. If the sheep is not worth the cost of such an operation, it should be sent to the butcher before the progress of the disease has rendered the animal unfit for food.

Prevention.—Smearing the nose of the sheep with a preparation that will prevent the fly from depositing its larvæ successfully on the nostril has been found to be a very satisfactory preventive measure and is one that is extensively practiced. Various preparations have been used, such as equal parts of tar and grease, of tar and fish oil, or of tar and whale oil; but the use of pine tar alone seems to be quite satisfactory. It is advisable to apply the tar by hand, at least the first time, and to make sure that it is applied liberally to the entire margins of the nostrils. The application may be renewed by hand later, as often as necessary, or may be automatically renewed by using a salt lick consisting of a thick plank or split log in which holes, 2 inches in diameter, are bored, with salt placed in the holes and the edges of the holes heavily tarred, so that the sheep get the tar on their nostrils as they lick the salt.

TAPEWORMS.

Adult tapeworms are usually composed of a head, armed with hooks and suckers as a rule (though those in the sheep's intestines have no hooks), and a body consisting of a number of flat segments arranged in a chain. Adult tapeworms are usually found in the small intestines, but in some cases they may occur in the stomach, large intestines, or the ducts of the liver and pancreas. Tapeworms produce eggs of microscopic size which pass out in the feces and which on being swallowed by a suitable host, usually of a sort different from the host of the adult tapeworm, give rise to an intermediate stage, or larva, which is usually more or less spherical or elliptical and composed of a tapeworm head and neck attached to a membrane, the membrane usually inclosing a clear fluid. In the case of many of the common tapeworms this form is called a bladderworm. It usually occurs in the body tissues, and when these are eaten by the host of the adult tapeworm the head of the tapeworm passes to the intestine and forms the adult worm by the addition of segments back of the head. This tapeworm in turn produces eggs and the cycle is repeated. Thus, certain tapeworms in the dog give rise to certain bladderworms in sheep, the tapeworm eggs in the feces of the dog being deposited on the pasture and picked up by sheep with the herbage that they eat. The dog in turn becomes infested with tapeworms when it eats the bladderworms in the meat, brain, liver, entrails, or other parts of the sheep.

Sheep may harbor adult tapeworms in the intestine and bladderworms in the body tissues.

THE MONIEZIAS.[8]

Location.—These tapeworms are found in the small intestines.

Appearance.—They are whitish to yellowish in color and may attain a length, in some specimens, of several yards (see fig. 13). The individual segments of a worm are broader than long, and each segment contains at some period of its development a complete set of reproductive organs. The end segments are full of eggs, and these segments break off from the rest of the worm and pass out in the manure, where they are often found by the farmer and regarded as complete worms. The presence of these segments in the feces serves to diagnose cases of infestation with the tapeworm.

Life history.—The life history of these tapeworms is not known. Sheep are herbivorous animals and would only by accident eat animals, such as insects, that might serve as intermediate hosts. It is possible that the intermediate hosts are small animals, such as insects, that are taken in by the sheep on grass, but we have no evidence on this subject.

[8] *Moniezia expansa, M. trigonophora,* and *M. planissima.*

Distribution.—These tapeworms are more or less common throughout the United States. Two of the forms (*M. expansa* and *M. planissima*) are also widely distributed outside the United States.

Symptoms and lesions.—When these worms are present in sheep in large numbers they cause obstruction of the intestine and intestinal irritation, with the result that they interfere with digestion and the sheep become unthrifty, weak, and emaciated; such sheep are unable to stand adverse conditions, such as bad weather or poor food, and die where sheep not so infested may survive. The digestive derangement is manifested by diarrhea as a rule. It is known that tapeworms often cause very marked and even severe nervous symptoms in man, and while such symptoms are more difficult to detect in sheep, there is every reason to suppose that they may occur.

On post-mortem examination of affected sheep the tapeworms are found in the small intestine, often in large numbers. The sheep show no special indications of their presence other than poor condition, evidences of diarrhea, and inflammation or catarrh of the intestines.

Treatment.—Various treatments have been recommended. Among the remedies which have been used are the following:

Kamala.—This drug has been given in doses of 1 dram to lambs. It causes diarrhea and lambs so treated may remain poor for some time in spite of abundant food and good conditions otherwise.

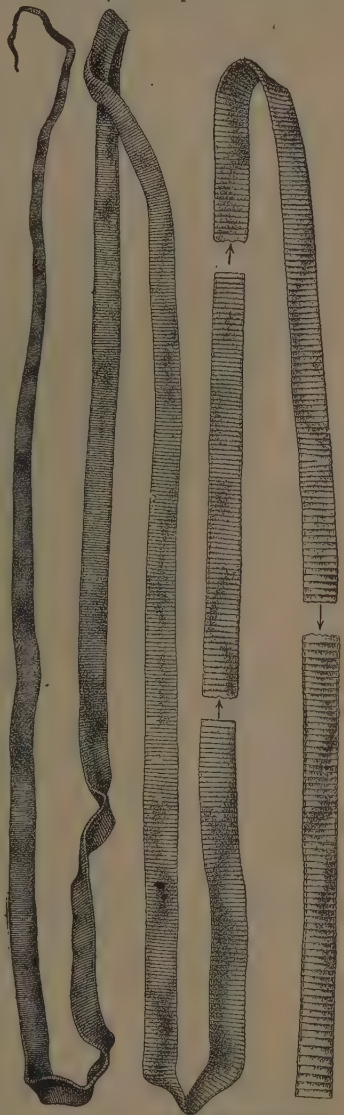

FIG. 13.—Tapeworm (*Moniezia trigonophora*). About natural size. (From Stiles, 1898.)

Kousso.—This is said to have given good results in doses of 2 drams to lambs.

Koussin.—This is reported as giving good results in 2-grain doses. It expelled the tapeworms, and the animals remained in good spirits and improved in condition.

Oleoresin of male fern.—This is given in doses of 1 dram and may be given with 2 to 4 ounces of castor oil.

Areca nut.—This may be given to lambs in doses of 1 to 3 drams. It must be freshly ground shortly before being used, preferably the day it is used.

The copper-sulphate treatment for stomach worms, given on pages 39 to 41, will also remove some tapeworms.

In South Africa good results have been reported from the use of a mixture containing 1 part of sodium arsenite (testing 80 per cent arsenious oxid) and 4 parts of copper sulphate. The total dose of the mixture is as follows: For animals 2 to 4 months old, 180 milligrams; 4 to 6 months old, 250 mg.; 6 to 10 months old, 375 mg.; 1 year old, 500 mg.; 2 years old or older, 625 mg. This may be given as a powder. Remove food and water the afternoon before dosing: dose the following morning; allow food that afternoon and food and water the next morning. The dose may be repeated the day after the first dose, in which case food is allowed the afternoon after the first dose, the animal is dosed the following morning and fed that afternoon, but no water is allowed from the afternoon preceding the first treatment until the morning following the second treatment. Owing to the poisonous nature of arsenic, it is best to test the treatment on a few sheep to be sure the dose is safe before dosing a flock, and the drugs should be kept out of reach of children and animals. If the treatment is repeated at intervals of a month or more through warm weather, the single treatment should be used.

The Oklahoma experiment station claims very good results from a solution containing 1 per cent copper sulphate and 1 per cent by weight of snuff or powdered tobacco. The tobacco is steeped overnight and the copper sulphate then added. The dose is 50 mils (about 1½ ounces) for lambs and twice this amount for full-grown sheep.

Prevention.—No dependable preventive measures against these tapeworms can be recommended, owing to the fact that the life history is unknown.

THE FRINGED TAPEWORM.[9]

Location.—This tapeworm is found in the small intestine, the gall ducts, gall bladder, and biliary canals of the liver, and in the duct of the pancreas.

Appearance.—These are whitish or yellowish tapeworms and may be a foot long (fig. 14), but are commonly shorter. They may be readily distinguished from other tapeworms by the fact that each

[9] *Thysanosoma actinioides*

of the segments has a fringe on its posterior border. This fringe may be most easily seen when the segment is put in water, where the fringes can float out from the segment. Tapeworms found in the liver or pancreas will be this worm and not the Moniezias already described.

Life history.—As in the case of the Moniezias (and this is true of all the adult tapeworms of cattle, sheep, and horses), the life history is unknown. Presumably it has an intermediate stage, perhaps in an insect or other small animal.

Distribution.—The fringed tapeworm is a parasite of western sheep and is found in the East probably only when the sheep have been shipped from the West. The infected range is probably confined to North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, and the States west of these. The parasite apparently has found conditions most favorable among range sheep, and it seems to be losing ground with the breaking up of the big western sheep ranges and the substitution of small holdings of sheep.

Symptoms and lesions.—The obstruction of the bile ducts and pancreatic ducts causes inflammation of these ducts and derangement of the liver. As a result there is an alteration in the secretions as regards amount and character, which impairs digestion and causes a lack of thriftiness. This shows in lost flesh and poor quality of flesh and wool. Sheep weakened by fringed tapeworms may die from the parasitic infestation or from inability to withstand other adverse conditions. Infested sheep are commonly hidebound and suffer from diarrhea.

On post-mortem examination the tapeworms may be found in the intestine and in the liver and pancreas, and the ducts of these glands are usually found thickened when infested. In the spring of the year fringed tapeworms seem more likely to be found in the small intestine than at other seasons.

FIG. 14.—Fringed tapeworm (*Thysanosoma actinioides*.) About natural size. (From Stiles, 1898.)

Treatment.—No successful treatment is known for this parasite. Such treatments as have been attempted have failed, and all that can be recommended at this time is careful nursing and good feeding.

Prevention.—As in the case of the Moniezias, the fact that we do not know the life history of this worm makes it impossible to give specific directions for preventing infestation.

BLADDERWORMS.

THE THIN-NECKED BLADDERWORM.[10]

Location.—The thin-necked bladderworm is found in the abdominal cavity attached to the mesenteries or omenta or in the liver.

Appearance.—The bladderworm looks like a sac full of a clear fluid, with a white object, which is the head and neck, projecting into it from one end. It is usually about 1 inch in diameter, but may attain a long diameter of several inches. The bladderworm proper is surrounded by a cyst, which is developed by the host animal as a protective measure against the parasite. When this cyst is broken the parasite usually rolls out and is seen to be a thin-walled structure. By careful manipulation the head and its rather long neck may be squeezed out at one end of the "bladder" (fig. 15).

FIG. 15.—Thin-necked bladderworm (*Cysticercus tenuicollis*). Natural size. (From Stiles, 1898.)

Life history.—If one of these bladderworms is fed to a dog the cyst wall will digest, but the tapeworm head and neck will pass on to the small intestine of the dog and begin to grow segments back of the neck. In this way it will form a tapeworm, one of the largest of the dog tapeworms[11] (fig. 16). This tapeworm attains a length of a yard or more, becoming mature and beginning to liberate egg-bearing segments in the course of 10 or 12 weeks. When dogs infested with these tapeworms run over pastures used by sheep, they leave feces containing the tapeworm eggs on the pastures, and these eggs are spread by rain and washed on to the grass and into streams and puddles where the sheep drink. When the sheep get these eggs in food or water, the embryo escapes from its surrounding shell, makes its way to the liver of the sheep, and begins to develop. In time it slips out of the liver and becomes attached to the mesenteries or omenta. At first it is a bladder without a head, but later the head and neck develop, and it is then ready to infect any dog that eats it.

Distribution.—This parasite is quite generally distributed over the United States, but the indications are that the worm is becoming less common as a result of improvements in disposal of viscera and offal at slaughterhouses during the last 15 years. It is most likely to be present where sheep are associated with dogs, either when herded by them or where stray dogs are common, and where sheep are slaughtered on farms or at small country slaughterhouses at

[10] *Cysticercus tenuicollis.*

[11] Commonly called *Tænia marginata*, and more properly *Tænia hydatigena.*

which little care is exercised in disposing of the viscera and of diseased portions of carcasses.

Symptoms and lesions.—Light infestations with these bladderworms seem to do very little damage. Severe infestations, such as a sheep would get by eating grass that had an entire segment full of eggs on it, will make a sheep very sick and may kill it. Under these conditions sheep usually die at a rather early stage of the disease, and at a time when the embryos are wandering around in the liver, the immediate cause of death being hemorrhage from the liver, or peritonitis. Post-mortem examination under these conditions would seldom be sufficiently minute to reveal the exact cause of the trouble, and it would seldom be charged to the account of this parasite.

On post-mortem examination the bladderworms are usually readily observed in the mesenteries or omenta, or in earlier stages, in the liver. When the liver has just recently been invaded, the presence of the parasite is usually indicated by serpentine markings showing the course of the wanderings of the young worms.

Treatment.—There is no treatment for infestation with the bladderworm in sheep.

Dogs should be kept free from tapeworms of any sort, including the one responsible for this bladderworm in sheep. For removing these tapeworms, fast the dog from noon of one day until the following morning and then give one of the following treatments:

Oleoresin of male fern.—The dose for dogs is 15 minims to 1 dram (a quarter of a teaspoonful to a teaspoonful), according to size. This may be given in capsules and followed immediately by an ounce of castor oil.

Areca nut.—This may be given in the same amounts as the oleoresin of male fern, and will usually not need a purgative, as

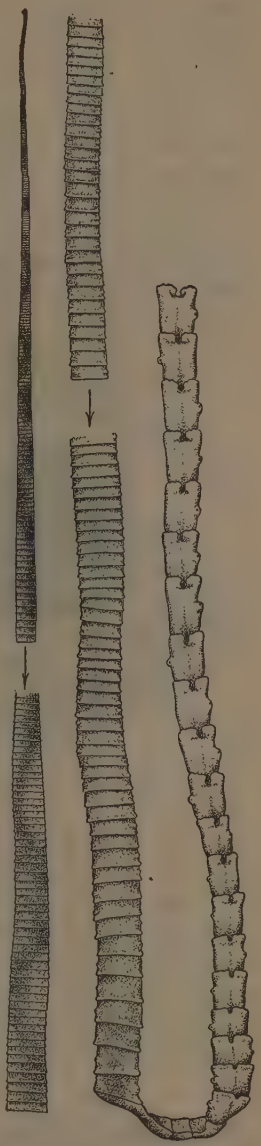

FIG. 16.—Tapeworm (*Tænia hydatigena*) of dog, developed from thin-necked bladderworm of sheep. About natural size. (From Stiles, 1898.)

areca is itself purgative. If feces are not passed in the course of four or five hours, it is advisable to give castor oil or some other purgative. As noted previously, areca nut must be freshly ground to be efficacious.

Arcoline hydrobromide.—For dogs of moderate size, one-fourth grain; for small dogs, one-eighth grain. No purgative should be given, as this drug is itself purgative.

Kamala.—This may be given in doses of half a dram to 2 drams (a half teaspoonful to 2 teaspoonfuls). The powder may be given in sirup and will not need to be followed by a purgative, as kamala itself is a purgative. As in the case of areca nut, if feces are not passed in four or five hours castor oil or some other purgative should be given.

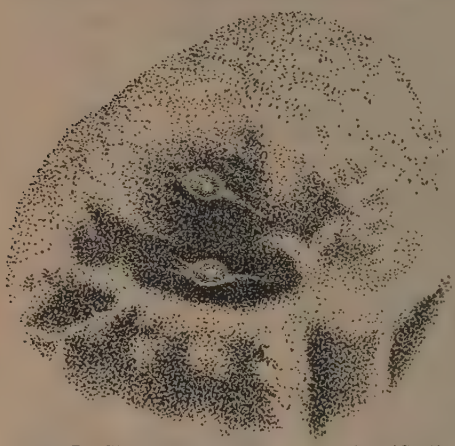

FIG. 17.—Sheep muscle showing measles (*Cysticercus ovis*). Natural size. (From Ransom, 1913.)

Any tapeworms that are passed and the feces with them should be burned. On the farm this is easily done by using hay or straw for fuel.

Prevention.—This consists in preventing dogs from eating uncooked meat, especially diseased and parasitized meat and viscera. Slaughterhouse refuse should be tanked and not left where dogs can have access to it. The use of the tank has apparently resulted in a diminution in the number of cases of this parasite in sheep and dogs, and the extension of this measure will probably eradicate it in time. Dogs should be kept free from tapeworms by suitable remedies, whenever necessary, and it would be advisable to give such treatment as a routine procedure about four times a year where there is any chance of dogs eating infective material. Stray dogs should be kept off farms and suppressed by appropriate measures.

SHEEP MEASLES.[12]

Location.—Parasites known as sheep measles occur in muscles, including the heart, and intermuscular connective tissue, and as degenerate cysts in the lungs, walls of the first and fourth stomachs, and the kidneys.

Appearance.—This parasite occurs in the meat (measly mutton) as oval cysts 3.5 to 9 mm. (one-seventh to one-third of an inch) long

[12] *Cysticercus ovis.*

by 2 to 4 mm. (one-twelfth to one-sixth of an inch) wide. These cysts have a thin external membrane inclosing a clear fluid. On one side of the cyst is an opaque white object, which is the head and neck of a tapeworm (fig. 17). When degenerated the cysts appear as cheesy or hard nodules, the hardness being due to lime salts.

Life history.—The life history of this parasite is similar to that of the thin-necked bladderworm, the adult being a certain species of tapeworm of the dog (*Tænia ovis*).

Distribution.—In the United States this parasite appears to be most common in the West, especially in Montana, Idaho, Washington, Oregon, California, Colorado, and Nevada. It has been found abroad in England, France, Germany, Algeria, German Southwest Africa, New Zealand, and South America.

Symptoms and lesions.—When sheep have but a few of these cysts no symptoms are likely to be observed, although it has been suggested that sheep measles may be responsible for the many stiff lambs found during spring and summer on the western sheep ranges. When many cysts are present sheep will become very sick, and if all the eggs from one segment are eaten by a sheep it is likely to die. On post-mortem examination the cysts are the principal thing observed, though in badly infested cases the meat may be watery and discolored.

Treatment and prevention.—These are the same as for the thin-necked bladderworm (pp. 25 and 26) and its adult tapeworm.

THE GID PARASITE.[18]

Location.—The gid parasite occurs in the brain or spinal cord. Degenerate worms that failed to reach the central nervous system may be found in muscles and other tissues.

Appearance.—This worm occurs as a large cyst or bladderworm, attaining the size of a hen's egg or larger, and is composed of a thin membrane containing a rather large amount of fluid. On the bladder membrane are a number of small white objects about the size of a grain of wheat, projecting, as a rule, into the bladder fluid (fig. 18). These are the tapeworm heads. A parasite of this sort is called a cœnurus.

Life history.—When such a bladderworm, or cœnurus, is eaten by a dog or coyote the bladder membrane digests, releasing the attached tapeworm heads. These heads then pass into the small intestine, where they form the adult tapeworm by the addition of segments back of the head (fig. 19). Ordinarily the worm is fully grown and 2 or 3 feet long in the course of a month or two, though occasionally a longer period is required. The full-grown tapeworm produces minute eggs, which pass out in the feces of the dog on to the pasture or range. Under favorable conditions these eggs are taken in by sheep with contaminated food or water. The shell

[18] *Multiceps multiceps.* Synonym, *Cœnurus cerebralis.*

digests from the egg and releases an embryo, which is armed with six hooks. By means of these hooks the embryo cuts its way through the tissues of the sheep and into the blood stream. In the blood the embryos are carried to various tissues, but only those that reach the brain or spinal cord are able to attain the full larval development, the others dying and degenerating by the time they reach the size of a pea. Those that reach the central nervous sys-

FIG. 18.—Gid parasite (*Multiceps multiceps*) from brain of sheep. Natural size. (From Hall, 1910.)

tem at first move about on or in the brain or spinal cord, forming curving channels. At a suitable point the wandering ceases and the bladderworm grows and completes its development in about seven or eight months, the sheep dying in nine months or earlier.

Distribution.—In the United States this parasite has been found chiefly in northern Montana, where it has been established for about 30 years, possibly longer. There have also been outbreaks of gid in Arizona and in New York. Cases have been observed also in various

localities to which sheep have been shipped from infested regions. Occasionally cases are imported from Europe. Outside the United States the disease is known to occur in England, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Sardinia, Switzerland, Greece, Spain, Holland, Denmark, Iceland, Shetland, Morocco, Cape Colony, German Southwest Africa, South Australia, New Zealand, Argentina, Chile, and Canada.

Symptoms and lesions.—At the time that the young worm gets to the brain there are usually slight symptoms of fever and restlessness, which are easily overlooked. If the sheep dies at this time, as a result of severe infestation, an examination of the brain will show a number of curving channels on its surface. As a rule the symptoms of this stage abate and there is no further indication of the presence of the parasite until it has grown to the point where the heads form. This will take place about the seventh or eighth month after infection. The head of the worm can be evaginated from the bottom of its tubular neck, just as a glove finger may be turned inside out, and this brings its hooks and suckers into contact with the brain. From this irritation and from the pressure of the growing bladderworm there arise the very striking symptoms indicative of gid. Affected sheep very commonly walk in a circle, turning toward the side corresponding to the affected portion of the brain when the parasite is on the surface of the cerebrum. When the parasite is located at other points the symptoms are somewhat different. In these cases sheep may walk with the head held high and may step high, or with the head held low and with a stumbling gait, or may show other odd symptoms in the way of unusual locomotion. Such animals gradually lose interest in food and water and finally cease eating or drinking. In consequence they become very much emaciated. They may move about continuously or stop at times and gaze fixedly at nothing in particular. They are difficult or impossible to herd and tend to lag behind the flock or become lost. The

FIG. 19.—Tapeworm stage of *Multiceps multiceps* in dog. Actual size. (From Hall, 1910.)

head is often carried to one side and the animal may become blind or appear to be blind.

Unless surgical treatment or accident frees the sheep from its parasite, the animal will die, usually in the ninth month. When examined after death, the brain or spinal cord will be found to have on or in it a bladderworm, or more than one, and an equal amount of brain or cord tissue will be found to have disappeared or been crowded aside by the growth of the cyst. The skull adjacent to the parasite is often softened or even absorbed to the point where it has a hole or several holes through it. In the late stages sheep are so emaciated that the meat is unfit for food.

Treatment.—The treatment for gid is surgical. This is satisfactory only when the cyst is on the surface of the brain. Operation may be performed with a trocar and cannula or with a trephine. In the trocar and cannula operation the wool is sheared over the affected area, as determined by the symptoms and by palpation to find a soft spot or one where the sheep reacts violently to pressure. Under local anesthesia the trocar and cannula are driven through the skull and the trocar withdrawn from the cannula. If the cyst is struck, a watery fluid will issue from the cannula. This fluid is syringed out and the cannula withdrawn. Suitable cannulas are provided with a cleft to catch the bladder membrane and pull it out. If this fails, it is necessary to remove the membrane with forceps or by some other means. This operation, like operations generally, should be conducted under aseptic conditions. The median line of the skull should be avoided.

With the trephine outfit the wool is sheared over the proper area and under local anesthesia and aseptic conditions a V-shaped incision is made through the skin and the skin dissected back. A piece of skull is then cut out with a five-eighths-inch trephine and the hard membrane covering the brain is cut with bent scissors. The parasite will usually push out and may be grasped with forceps and removed. If it does not appear, it may be necessary to explore for it with the finger. After removing the parasite and controlling the hemorrhage, the skin flap may be sewed back along one side of the tip of the V, and the wound covered with a pledget soaked in some antiseptic. The animal should be kept quiet in a dark shed for several days after operation.

Some sheepmen cut the skull with a pocket knife or puncture the cyst with a knife. In such cases the sheep is apt to die of infection, even if the worm is removed. The operation for gid calls for care and should be performed by a competent veterinarian. If operation does not seem to be feasible, it is advisable to kill giddy sheep for mutton or send them to market before they become emaciated and unfit for food.

Prevention.—The most important preventive measure is to destroy the heads or at least the brains of giddy sheep. This may be done by burning. Where wood is scarce the skull may be split with an ax or cleaver and the brain put on a forkful of hay or straw and burned. Where this is not feasible the brain may be removed from the skull, crushed, and covered with formaldehyde, turpentine, or a coal-tar or tobacco dip. The essential thing is to destroy the parasite and prevent dogs, coyotes, or other animals from eating it.

Another measure of importance is to keep dogs, especially sheep dogs, free from tapeworms. To this end it is advisable that they be given tapeworm treatment four times a year. For the treatments that may be used see page 25. Measures against coyotes and other noxious wild animals are valuable in controlling gid as well as in keeping down the destruction of stock. Stray dogs should be eliminated on the same grounds.

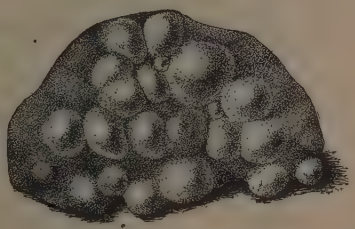

Fig. 20.—Hog liver infested with hydatid (*Echinococcus granulosus*). Greatly reduced. (From Stiles, 1898.)

THE HYDATID.[14]

Location.—The preferred sites of the hydatid parasite in sheep are the liver and lungs, but it may occur in practically any organ or tissue.

Appearance.—The parasite occurs in sheep usually as a multiple bladderworm, varying from the size of a nut to the size of a child's head, sometimes as a spherical object and sometimes irregular in shape (fig. 20). It has a very thick, laminated bladder wall, and in the simplest form of the parasite this bladder contains a clear fluid and minute objects resembling grains of sand lying unattached in the fluid. These grains are brood capsules, and each of them contains a number of very small tapeworm heads. Sometimes the bladderworm develops other bladderworms, attached or unattached, on the inside or outside.

Life history.—When the brood capsules from a hydatid are eaten by a dog, cat, or other suitable animal, each tapeworm head in the brood capsules develops into a tapeworm by the addition of segments back of the head. This tapeworm is a very small one, less than half a centimeter (about one-fifth of an inch) long (fig. 21). As the hydatid may form thousands of such heads in its brood capsules, dogs may become infested with large numbers of these worms on eating hydatids. The eggs produced by the adult tapeworms in the dog pass out in the feces. When taken in by a sheep or other animal the egg hatches and releases an embryo which makes its way to some

[14] *Echinococcus granulosus.*

suitable tissue and develops to the hydatid. This hydatid may develop in man if an egg of the tapeworm is swallowed, and a large percentage of hydatid infestations in man result in death. It is therefore a very dangerous parasite to human beings.

Distribution.—This parasite has been found at a number of places in the United States proper and in Alaska, as well as in other parts of the world. Certain regions are found to send a large number of infected swine to the slaughterhouses, though its occurrence in sheep is comparatively rare in the United States. Where it is locally prevalent, its abundance may be attributed to infected dogs which have probably become infected through carelessness in the disposal of diseased carcasses and viscera of slaughtered animals. Careless persons may feed diseased portions of carcasses to dogs or leave them where dogs will get at them and eat them.

FIG. 21.—Hydatid tapeworm (*Echinococcus granulosus*). Highly magnified. (From Stiles, 1898, after Leuckart.)

Symptoms and lesions.—The symptoms in sheep affected with hydatid depend on the location of the parasite and its size, and so are very variable. Where the parasite is small or has room to develop without crowding important organs, few symptoms may be noticed. On the other hand, the parasite may develop in such structures as the brain or heart and cause very marked symptoms and sudden death from pressure or rupture. As a rule, infestations will not be detected and correctly diagnosed during the life of a sheep and they will be found only on post-mortem. In such cases the large, thick-walled bladders are readily found.

Treatment.—The only treatment for this condition is surgical, and this is not apt to be feasible in sheep, even if the disease should be diagnosed ante-mortem.

Prevention.—The most important measure in the way of prevention of this disease is the proper disposal of carcasses and portions of carcasses of animals dying on the farm or killed there or elsewhere. The "condemned" tank at the modern slaughterhouse has been one of the greatest factors in destroying parasites of this sort, and the lack of an equally good arrangement at the small country slaughterhouse and on the farm is one of the important conditions which permit such parasites to persist. Where diseased viscera, such as livers infested with hydatid, are thrown out where dogs can get at them, parasites of this kind are liable to be prevalent. The next measure of importance in controlling this disease is to keep dogs free from

tapeworm by administration of tapeworm treatments four times a year. For these treatments, see page 25. Owing to the danger of persons acquiring hydatid diseases and the serious nature of this disease in man, dogs known to harbor this tapeworm should be killed and burned or buried deep in quicklime.

FLUKES.

Flukes are usually flat, leaflike animals, provided with suckers, but not segmented like the tapeworms. They occur in the adult stage in various locations, the stomach, intestines, liver, lungs, and blood vessels, and may occur in immature stages in such tissues as the muscles. The adult flukes produce eggs of microscopic size which pass out and hatch in water. The embryos released from the eggs infect snails in which they transform into a succession of larval stages. The parasites finally escape from the snails and may penetrate the skin of the final host or may be swallowed, sometimes after encysting, in food or water.

Sheep in certain localities in the United States, as well as in other parts of the world, suffer considerably from fluke infestation. The common liver fluke and the large liver fluke occur in American sheep.

FIG. 22.—Common liver fluke (*Fasciola hepatica*). Natural size. (From Stiles, 1898.)

THE COMMON LIVER FLUKE.[15]

Location.—These flukes are found usually in the biliary canals and the ducts of the liver, though they may occur as wandering parasites in the lungs and elsewhere.

Appearance.—The common liver fluke is a flattened, leaflike, brown animal, usually about an inch long (fig. 22). There is a sucker at the anterior, or front, end, on a cone-shaped extension, and just behind this is a ventral sucker. Through the skin or cuticula covering the animal one can see the branching intestine and the uterus filled with eggs.

Life history.—The eggs produced by the adult flukes pass out in the feces and on getting to water release a ciliated embryo. This embryo attacks certain species of snails and on entering the snail undergoes certain changes, which in time give rise to a form called a cercaria. This is like a small fluke provided with a tail by means of which it swims about. Finally it loses the tail and encysts. The encysted cercariæ may float about on or in water or may be attached to grass blades or other vegetation. When these are swallowed by sheep, or other suitable host animals, the larval flukes escape in the digestive tract and bore their way through the intestinal

[15] *Fasciola hepatica.*

walls to the body cavity. Here they wander over the surface of the viscera and the walls of the body cavity and as a rule finally perforate the capsule of the liver and reach the extremities of the biliary canals. A few go astray and perforate the diaphragm, getting to the lungs. In the liver the young flukes grow and make their way down the canals, the larger ones being found in the bile ducts, and begin again the life cycle with the formation and passage of eggs.

Distribution.—This parasite occurs over a large part of the world, where low, wet pastures and the presence of suitable snails make it possible for it to exist. In the United States it occurs on the Atlantic and Pacific coasts in places, and along the Gulf of Mexico. In these regions it occurs in wet pastures, especially along rivers and tributary streams. The States in which the fluke is most prevalent are Washington, Oregon, California, Texas, Arkansas, Louisiana, Alabama, and Florida. It is also prevalent in Porto Rico and Guam.

Symptoms and lesions.—Sheep are likely to put on fat and seemingly improve in condition in the early stages of liver-fluke disease, usually in the summer and fall, apparently as a result of a stimulation of the functions of the liver. Later, however, they lose in condition. The skin and mucous membranes are paler and the animal is less lively. The animal feeds less and ruminates less. Edema appears as the composition of the blood is altered, and may be seen as swellings along the pendant portions of the body, for example, in the region under the jaw. During the winter the sheep becomes leaner, breathes rapidly and feebly, and is dejected. A diarrhea is usually present at a late stage of the disease.

Animals may die at any stage of the disease, but if they survive the attack the flukes leave the sheep in the spring and a part of the damage is repaired. Total recovery is hardly possible, as the liver is burdened with scar tissue in the areas where the flukes have been. The disease may be diagnosed from its symptoms, if one is familiar with it, but a safer diagnosis is based on the finding of the worm eggs in the sheep manure.

For the purposes of the farmer and sheepman the surest diagnosis is made by killing a sick sheep and making a careful post-mortem examination. If the ducts of the liver are carefully slit and examined, the flukes will be found as dark, leaflike objects which, if watched a short time, will show movement. The liver may be washed in a plentiful supply of clear water as it is cut up, and the water examined for the flukes that may wash out. The liver of infected sheep is softened and roughened, and may show channels under its capsule. In old cases puckered scar areas are present.

The softening of the liver is what gives the name of "liver rot" to the disease. The biliary canals and gall ducts are much thickened and enlarged and often are marked by ridges on the surface of the liver.

Treatment.—The two remedies which have been found satisfactory are male fern and kamala. According to some writers, however, kamala is much less efficacious than male fern.

Oleoresin of male fern is administered as follows: Give by mouth 3 to 5 grams of the male fern (from ¾ of a teaspoonful to 1¼ teaspoonfuls), according to the size of the sheep, in 10 mils (2½ teaspoonfuls) of a nonpurgative oil, in the morning, two hours before feeding. Administer the treatment on five consecutive mornings. The male fern should contain 24 to 25 per cent of filicine and 3.5 per cent of filicic acid.

Powdered kamala is administered as follows: To yearlings and older sheep give 15 grams divided into two doses of 7.5 grams (2 drams) each, and give at 12 to 24 hour intervals. The entire 15 grams may be given in one dose to a strong animal or divided into five doses for weak ones. After treatment sheep are dull for 3 to 5 days, they lie down a great deal, eat little or may stop eating for a day or two, and have a diarrhea. The flukes are said to die in 3 to 8 days.

It is advisable to have these drugs administered by a competent veterinarian.

Prevention.—The manure from infected sheep should not be put on pasture, especially on wet ground. Sheep should be kept off wet pasture in places where fluke is prevalent and swampy areas should be drained, filled, or fenced off. Dressings of lime and salt on pastures in June, July, and August have been recommended for killing the embryos and larvæ of the fluke and for killing and repelling snails. It is said that sheep never become infected with flukes on salt marshes. Infected sheep should be isolated and either treated for fluke or butchered before they have lost condition and become unfit for food. Where fluke is present in a flock, it is advisable to treat the flock at the beginning of winter after the danger of fresh infestation is past. Frogs, toads, and carp are useful in the control of snails. Safe drinking supplies must be provided for sheep as the infection may be water-borne.

The Oregon agricultural experiment station has recently recommended the addition of copper sulphate (bluestone) to standing water or streams in pastures to destroy the snails which are the necessary intermediate hosts of liver flukes. After ascertaining the volume of standing or running water to be treated, add one ounce of copper sulphate to 7,800 gallons of water or about one part of copper sulphate to one million parts of water. This will kill snails in 48 hours, but

will not not kill the eggs. Repeat this treatment in two or three months, after the eggs hatch. The solution is not injurious to the higher plants and animals or for bathing, drinking or irrigation, but it may injure fish.

THE LARGE LIVER FLUKE.[16]

Location.—The large liver fluke occurs in the liver, commonly lying in cysts which contain one to several flukes and a quantity of dark-colored fluid filled with débris. While these cysts may originate in a biliary canal, they extend into the tissue, and the fluke is habitually found as a parasite in the liver substance in cysts and not as a parasite of the canals and ducts. Wandering flukes may be found in the lungs or elsewhere.

FIG. 23.—Large liver fluke (*Fascioloides magna*). Natural size. (From Stiles, 1898.)

Appearance.—This is a large, thick species, which may attain a length of 10 cm. (4 inches) (fig. 23). The anterior, or front, sucker is not carried on a distinct cone, as in the case of the common liver fluke, but in its general appearance otherwise it resembles an overgrown specimen of the common liver fluke.

Life history.—The life history of the large liver fluke has not yet been ascertained, but there is every reason to suppose that it is much the same as that of the common liver fluke, with snails of some sort, perhaps the same as those which carry the common liver fluke, as intermediary hosts.

Distribution.—North America appears to be the home of this fluke, although it has been transplanted elsewhere. In the United States it is most prevalent near the Gulf of Mexico, especially in Arkansas and along the coasts and river valleys of Texas. It also occurs along the west coast in both the United States and Canada and seems to have obtained a foothold at some inland points, as in part of Colorado. Cases are also reported from Wisconsin and New York.

Symptoms and lesions.—This parasite is much more common in cattle than in sheep. It seems to do rather little damage in cattle apart from rendering the livers unfit for use as food. In sheep, however, it may do considerable damage. Infected sheep lose condition, but the appetite persists up to the time of death. Edema is present in the form of watery swellings of the dependent portions of the body. Abortions have been reported as prevalent in a flock of infested sheep, though it is unsafe to associate this with the fluke without further evidence.

[16] *Fascioloides magna.* Synonym, *Fasciola magna.*

On post-mortem examination the livers show the characteristic cysts or else dark-bluish scars where the flukes have been and where healing has taken place. The flukes apparently die in the liver instead of passing out in the spring, as the common liver fluke does. The cysts take on the character of abscesses and may be present in the lungs and spleen as well as in the liver. Affected livers and other organs contain more or less coal-black pigment characteristic of the presence of this parasite. The worms may set up peritonitis, and the omentum may show black markings.

Treatment.—No treatment is known for this disease, though the use of oleoresin of male fern or kamala is indicated as for the common liver fluke.

Prevention.—The same measures that are used in the case of the common liver fluke (see p. 35) are indicated here. As already noted, while we do not know the life history of this fluke, the probabilities are that the measures indicated will apply.

ROUNDWORMS.

The parasitic roundworms or nematodes are elongated, cylindrical, unsegmented worms. Some of them may be properly characterized as threadlike or hairlike. The body wall is usually rather transparent, and when the worms are examined with a microscope the internal organs are readily seen, usually in the form of a number of tubes. The sexes are generally separate and the males are usually smaller than the females. In general the females produce large numbers of eggs, though sometimes the eggs hatch in the body of the female and some roundworms produce embryos without the previous formation of an egg with its yolk material and shell.

Most of the roundworms of sheep reach the animal in which they develop to maturity through the direct swallowing of the eggs or young worms without passing through part of their development in some intermediate host, as the tapeworms do. In some cases the young worms that have hatched in the fields penetrate the skin of the host animal, entering the body in this way instead of by the mouth. Other worms have an intermediate host and undergo a certain development in this host before getting to the final host. The intermediate host harboring the larval worms may be eaten by the final host, thus infecting it through the digestive tract, or such intermediate hosts as mosquitoes may infect the final host by inoculating it with the larval worms which then penetrate the skin.

Even in the case of direct infection, when eggs or young worms are swallowed by the host animal, nematodes which develop to maturity in the intestine may not go directly there and develop immediately. They may pass through the walls of the digestive

tract and get to the blood stream, leave the blood stream for the air passages of the lungs, crawl up the windpipe, and then pass down the esophagus or gullet, and thus reach the intestine again, where they continue their development to maturity.

THE STOMACH WORM.[17]

Location.—This worm is a parasite of the fourth stomach. It may be found elsewhere in the digestive tract, but such occurrences are of little significance.

Appearance.—Stomach worms (fig. 24) are from one-half to 1¼ inches long and about as thick as an ordinary pin. The females are the larger and have a spiral striping. In the rear half of the body of the female there is a projecting portion, which may be seen on close examination. The smaller male may be distinguished by the

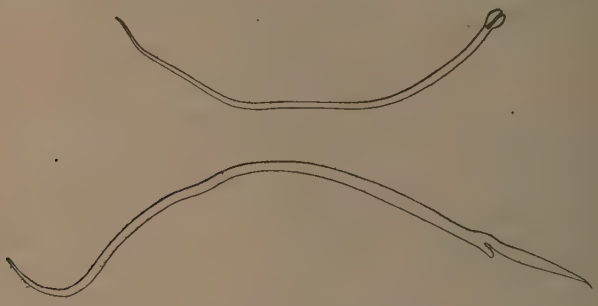

FIG. 24.—Stomach worms (*Hæmonchus contortus*). Upper figure, male; lower, female. Magnified five times.

fact that the posterior or tail end of the body is flattened and expanded.

Life history.—The eggs produced by the female worms pass out in the manure and hatch in a few hours under the most favorable conditions of warmth and moisture. Under less favorable conditions hatching may require a number of days or even weeks. The embryo which leaves the egg undergoes further development until it becomes an ensheathed, infective larva. In this condition it is inclosed in a double skin and is very resistant. Whereas drying and low temperatures may kill the egg or embryo previous to this stage, the ensheathed larva can withstand severe cold and long periods of dryness. When the grass is wet with rain or dew, these larvæ crawl up the blades. Here they are swallowed by sheep as they graze. In the stomach the worms become mature in the course of two to three

[17] *Hæmonchus contortus.* For additional information see Department Circular 47 on "Stomach Worms in Sheep."

weeks, but do not begin to produce eggs in large numbers until about a month after they are taken in by the sheep.

Distribution.—The stomach worm occurs over almost the entire world, wherever there are sheep, cattle, or other suitable host animals. In the United States it is most plentiful in the South, where it is favored by abundance of warmth and moisture, but it is quite a common and serious pest in the Middle West and in low, wet areas throughout the entire country. It is present in smaller numbers and does less damage in the high, dry, and cool areas of the Rocky Mountain States.

Symptoms and lesions.—The first things noticed about infested sheep are dullness and lack of thrift. Diarrhea may be present. Later, the more characteristic features of stomach-worm disease become evident in the form of anemia and edema. The anemia is manifested in the paleness of the skin and of the linings of the mouth and eyelids, and is due to the impoverishment of the blood from the bloodsucking habit of the worms. The edema is manifested in a swelling of the pendant portions of the body, especially of the portion under the jaw, causing what is called "bottle jaw." Sheep may become emaciated and finally die.

If the fourth stomach of a sheep infested with stomach worms is opened (the fourth stomach is the one to which the upper end of the small intestine attaches), the worms can usually be seen as wriggling red objects. When the contents of the stomach are poured out many of the worms will usually remain attached to the lining of the stomach. A little careful washing will reveal the worms if they are covered by the stomach contents. Close investigation of the lining of the fourth stomach will also reveal the pin-point punctures caused by the bites of the worms. There are usually a number of these for every worm, as the worm has the habit of attaching at one point for a time and then moving away and attaching at another point, leaving the old point of attachment bleeding for some time. The carcass of a sheep seriously infested with stomach worms is liable to be emaciated and the meat pale.

Treatment.—A satisfactory treatment for this disease is the use of a 1 per cent solution of copper sulphate in water. A dose which has been found satisfactory is 100 mils (about 3 ounces) for yearlings and older sheep and half as much for lambs 3 months old or older. To make this solution, dissolve one-fourth pound of copper sulphate in 1 pint of boiling water, then add cold water to make a total of 3 gallons of the solution. Porcelain or enamel-ware receptacles should be used for the solution, as bluestone (copper sulphate) will corrode metal. This amount will dose 100 adult sheep, allowing 10 per cent waste. Use only clear blue crystals of copper sulphate,

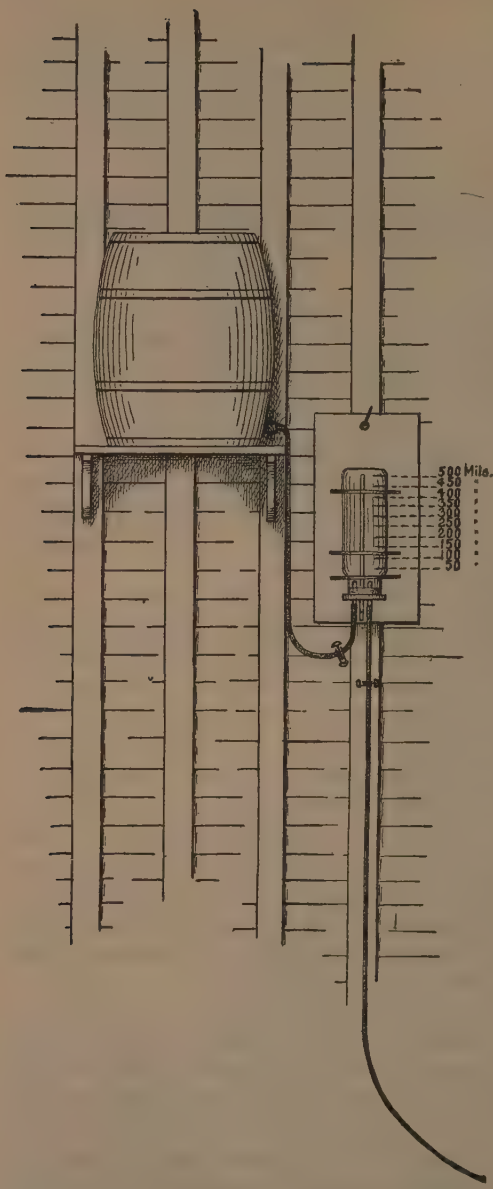

FIG. 25.—Dosing device for administering copper-sulphate solution.

discarding the pieces that have turned white. Crushing the crystals will hasten solution. In dosing, one may use a rubber tube with a funnel on one end and a piece of metal tube at the other. The metal tube is placed in the sheep's mouth and the solution slowly poured through the funnel. If large numbers of sheep are to be treated, the apparatus figured (fig. 25), or something similar to it, may be used. The copper-sulphate solution is fed from a high reservoir, by siphoning or by a tube or spigot near the bottom, through a rubber tube into an open graduated glass tube, which may be made from a large olive jar, and allowed to escape in measured doses through the other rubber tube to the metal tube in the sheep's mouth. Instead of an open graduated glass tube, a large bottle or jar may be used if a third tube is put in the jar, through the cork, one end being open to the outside and the

other opening near the bottom of the inverted jar, to equalize air pressure. This is shown in figure 25. The flow into and out of the glass tube is controlled by pinchcocks, one person attending to this and one holding the metal tube in the sheep's mouth. The sheep should remain on all four legs, with the head held horizontally while it is being drenched, which decreases the danger of getting the drench into the lungs and killing the sheep. The solution should be allowed to flow slowly and the metal tube be moved about slightly in the mouth at the same time in order to keep the sheep swallowing. It is essential that the copper-sulphate solution be made up accurately, be given in suitable doses, and be administered with care, and it is advisable to have a competent veterinarian give this treatment or the ones noted below in order to insure a maximum degree of safety.

The sodium-arsenite and copper-sulphate mixture and the copper-sulphate and tobacco solution, recommended for tapeworm, have also been recommended as effective against stomach worm (p. 22).

Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 fluid ounces of castor oil has been found to remove all stomach worms from sheep in experimental tests. See remarks under "The nodular worm," page 42.

Prevention.—Preventive measures are based on the life history. We know that the disease is spread by eggs produced by the female worm, which escape in the manure on to the pastures. Infested sheep must be regarded as a danger to young and uninfested sheep. The manure from the infested sheep is likewise dangerous. Consequently, young animals and uninfested sheep should be separated from older or infested animals and not exposed to contact with the manure from these animals. Furthermore, pastures which have been used by infested animals are dangerous to young animals and uninfested ones. When animals that have stomach worms, either in a light or heavy infestation, are put on clean pasture, the eggs of the stomach worm will hatch on the ground and the infective stage of the worm will be present on the grass in considerable numbers in from 10 to 20 days, or even earlier in warm weather. The longer the sheep are on that pasture under ordinary weather conditions the more dangerous it will become from the increasing number of worms. To prevent getting dangerous infestations, it is advisable that sheep be moved every two weeks to clean pasture. Inasmuch as pastures probably remain infected for about a year after sheep, goats, or cattle are moved from them, the program of moving sheep to new pasture, where permanent pastures are used, is a rather difficult one and calls for more land than is usually available. Consequently a modification of this program is necessary.

The first essential is to protect the lambs. Young animals are more susceptible to parasitic infestation than older ones. They also suffer more from parasites when they are infected. Growth must be made during youth; it can not be made up in mature years. Parasites interfere seriously with growth and lead to the production of runts. Consequently the safest pasture should be furnished to the lambs,

the older sheep taking the more dangerous pasture, where it is necessary for sheep to go back to old pasture within a year. It may be mentioned in passing that hillside pastures are likely to be safer than bottom land, as they benefit by the cleansing action of heavy rains and the following run-off, as well as holding less moisture, lack of moisture being very unfavorable to the worms. Rich bottom pastures, on the other hand, are the ones which are least likely to have an infection washed off and are likely to have the eggs and larvæ from the hillsides above washed on to them. The more or less abundant moisture, moreover, is highly favorable to these worms. It is precisely these bottom pastures which are likely to be used for young animals, as they present the best growth of grass and are most attractive.

In a plan of rotating pastures to keep down stomach worms, the sheep may be moved over cornfields, hayfields, and stubble of various sorts. During freezing weather, the eggs and nonresistant early stages of the young worms on pasture diminish as they are killed by freezing, so that the pastures at this time, while still infected, do not become increasingly dangerous. Plowing is a means by which infestation may be controlled, the young worms being turned under and buried; apparently they do not get back to the surface in numbers sufficient to cause serious trouble. Such plowed land may be sown to forage crops and the sheep turned in on these crops with safety. When different kinds of stock are rotated on pastures, sheep may safely follow horses or swine, but not cattle or goats, as these latter also may be infected with stomach worms and a number of other worms common to sheep, goats, and cattle.

At the Bureau of Animal Industry sheep farm at Vienna, Va., it has been found highly beneficial to dose sheep with copper-sulphate solution once every three or four weeks throughout the year, sheep thus treated showing no losses from stomach worms and making decided gains in wool and mutton over sheep kept under the same conditions but not treated. This appears to be the best control measure for use in the case of sheep kept under the usual farm conditions.

THE NODULAR WORM.[18]

Location.—The adults of the nodular worm live in the large intestine of the sheep. The larval worms live in nodules in the wall of the large and small intestine, and occasionally make their way to the mesenteric lymph glands, the omentum, or the liver. The nodules are most numerous in the wall of the large intestine.

Appearance.—The female worms attain a length of 15 mm. (about five-eighths inch), the males being a little shorter (fig. 26). Both sexes have a characteristic solid white color. The head is bent over and forms a hook with the body.

Life history.—The details of the life history of this worm are not completely known. The eggs from the female in the large intestine

[18] *Proteracrum columbianum.* Synonym, *Œsophagostomum columbianum.*

of the sheep are passed in the manure. The subsequent development of the worm up to the time it is again found in the sheep has not been determined. When the young worms are first found in the sheep they are encysted in the wall of the intestine. These cysts commonly reach a considerable size and contain a necrotic material, usually yellowish or greenish in color, cheesy in consistence or often hard and almost stonelike (fig. 27). After a time the larvæ leave these nodules and become adults in the lumen of the large intestine. Usually larvæ can be found only in the smaller and more recent nodules. Those larvæ which get to the mesenteric lymph glands, the omentum, and the liver probably die in these places and never get back to the intestine to complete their development.

Distribution.—This parasite was originally present in this country only in the Southern and Eastern States, but it has been spreading westward, probably with infested sheep introduced into western localities for breeding purposes, and there is reason to fear that it will become generally distributed over the country. It has become rather common in the Middle West, and is a serious pest in the Northeastern States. It is still uncommon in the Rocky Mountain States, and as yet has not been reported from a number of these States.

FIG. 26.—Nodular worm (*Proteracrum columbianum*). Upper figure, male; lower, female. Magnified five times.

Symptoms and lesions.—According to one investigator (Curtice) the symptoms of this disease may be only those of general debility—a pale mucous lining of the eyelids and mouth, emaciation, dry wool, etc. In severe cases diarrhea and emaciation may be excessive. In some places sheep raising has been abandoned on account of the damage done by this worm. It is evident that the injury due to numerous intestinal nodules, which prevent large areas of the intestine from functioning properly in the work of secretion and absorption, which act as persistent irritants to the sensitive nervous system of the digestive tract, and which serve to supply poisonous material from worms, bacteria, and dead tissue to the adjacent absorbing tissues of the intestines, can not fail to have a bad effect on the host animal. The resultant loss can not be accurately stated, but it occurs in terms of meat, wool, decreased growth, and poorer quality of animals and from the fact that nodular intestines, or so-called "knotty guts," are unfit for sausage casings.

The post-mortem lesions are easily seen, the principal ones being the nodules, which may be larger than a good-sized pea, on the walls of the large and small intestines, or in the mesenteric lymph glands,

the omentum, or the liver. The nodules may be small, elevated objects, or may be larger and contain cheesy or limy matter, white, greenish, or yellowish in color. These nodules are sometimes mistaken for lesions of tuberculosis, a rare disease in American sheep.

Treatment.—As yet we have no satisfactory treatment for this disease. The larval worms in the nodules are beyond the reach of any remedies as yet known to us. Even the adult worms in the large intestine are difficult to remove. There is some difficulty in getting a suitable drug past the four stomachs of a ruminant and into the large amount of food matter in the large intestine in sufficient strength to remove these worms. Experiments in the Bureau of Animal Industry have indicated that carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams), given in 2 ounces of castor oil, will sometimes remove all the nodular worms present in

Fig. 27.—Sheep intestines showing lesions of nodular worm disease.

an animal, but may remove only a small percentage. This treatment will also remove all the stomach worms and hookworms, as a rule, and will remove many of the thread-necked strongyles and related worms, and many whipworms. The carbon tetrachlorid treatment is new and requires further study to determine the safety of the treatment. It is advisable to secure prompt purgation with carbon tetrachlorid. The treatment should be administered by a competent veterinarian.

Prevention.—Pasture rotation, as given in the case of the stomach worm, is a valuable control measure. Dalrymple found that he could practically prevent the nodular worm infection of lambs by raising them in bare lots, where there would be no temptation to graze and where surroundings would be unfavorable for the development of the parasite. The ewes were let into these lots whenever necessary to nurse the lambs. The lambs were given other feed from raised racks and watered from raised troughs. The racks and troughs were protected from fecal contamination and the floor of the yard

cleaned frequently to keep it free from litter and manure, thereby preventing the development of the eggs in the manure in the yards. As in most parasitic diseases, the young animals suffer more than older ones and measures must be directed especially to the protection of the lambs. If persisted in, these measures and pasture rotation should keep the infestation down to a point where it does little damage.

THE SHEEP HOOKWORM.[19]

Location.—Hookworms of sheep are found in the small intestine.

Appearance.—The female hookworm attains a length of 2.6 cm. (about 1 inch), the male attaining a maximum length of 1.7 cm. (fig. 28). The worms are about one-half to three-fourths as thick as an ordinary pin. At the head end is a mouth capsule armed with teeth. The tail end of the male is expanded and flattened.

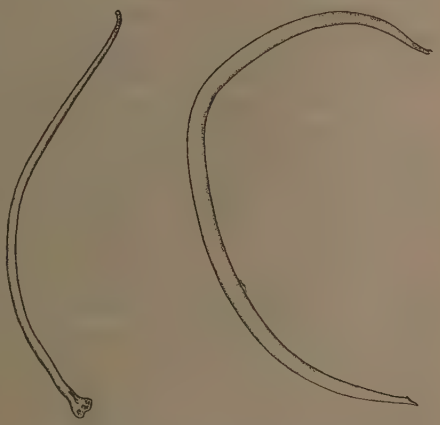

FIG. 28.—Sheep hookworm (*Bunostomum trigonocephalum*). Female at right; male at left. Magnified. (From Ransom, 1911.)

Life history.—The life history of the sheep hookworm has received little attention, but, judging from the life history of related forms, it is probably about as follows: The eggs produced by the female worm in the intestine of the sheep pass out in the manure and hatch on the pasture. Under favorable conditions of temperature and moisture the young worms develop to a resistant form capable of infecting sheep. Possibly most of the infection takes place by way of the skin, the larval worms boring through the skin of the lower part of the legs and making their way to the near-by blood vessels. In the blood the worms would be carried to the lungs, where they would escape from the blood and get into the air passages. Here they would make their way up the windpipe and then down the gullet into the stomach and intestine. When they reach the intestine they develop to adult worms and the two sexes mate. In addition to the possible entrance of larvæ through the skin, many of the infective larvæ on the pasture are undoubtedly swallowed by the sheep in food or water, but even in this case it is possible that the larvæ make their way to the blood stream

[19] *Bunostomum trigonocephalum*. Synonym, *Monodontus trigonocephalus*.

from the digestive tract and return by way of the lungs again before developing to maturity.

Distribution.—This parasite is common in sheep in the Southern States and has been found as far north as New York. Additional studies in various localities would doubtless show a wider distribution. It is apparently fairly common in Europe.

Symptoms and lesions.—The symptoms resulting from infestation with the sheep hookworm have not received much attention, but its habits are similar to those of the hookworm in man and in the dog, and these are known to cause very serious damage, so that there can be little question as to the damage that hookworm may do in sheep. The worms are bloodsuckers, with the habit of attaching for some time at one place and then moving to another, leaving the first puncture still bleeding. This bleeding persists for some time, as the result of a secretion from the mouth parts of the worm which has the power to dissolve the blood corpuscles and prevent clotting.

With hookworms in general it is not uncommon to see 10 or 12 hemorrhages associated with a single worm. This loss of blood results in its impoverishment, as well as in a net loss in amount of blood present. This in turn causes a seepage of the thinned blood out of the blood vessels and into the tissues, causing watery swellings, or edema, of the pendant portions of the body, as well as an associated condition, or dropsy, within the body. With the impoverishment of the blood the nutrition of the animal is impaired—a a very serious matter with young animals. We may safely infer that there is serious damage to the sheep's nervous system, preventing its smooth functioning and making for poor animals and poor offspring.

The things that may be looked for in connection with hookworm disease are paleness of the mucous lining of the eyelids and mouth, pale skin, dry wool, watery swellings under the jaw and along the abdomen, and a general condition of unthriftiness. The condition is very similar to that found in stomach-worm disease, as the two worms affect the host animal in substantially the same way. As it is usually complicated with stomach-worm disease, hookworm infestation is not apt to be recognized as a distinct disease. The only way to make a satisfactory diagnosis between the two conditions is by a post-mortem examination of the fourth stomach and the small intestine in order to ascertain which of the worms is present. In some cases both species of worms will be found and the results may be attributed to the mixed infestation. The lesions caused by the hookworm are red spots, or small hemorrhages, in the small intestine, while similar spots in the fourth stomach are caused by stomach worms.

Treatment.—Oil of chenopodium (American wormseed oil) in doses of about 1 dram (1 teaspoonful) in about 5 ounces of milk

has been found experimentally to remove about two-thirds of the hookworms present, and petroleum benzine (a high-grade gasoline) has been found to remove about three-fourths of the worms when given in doses of a half ounce in milk. In view of the greater safety in the use of chenopodium, this remedy seems preferable. A second treatment may be given after a lapse of two weeks. The copper-sulphate and tobacco solution recommended for tapeworms has also been recommended for hookworms.

Carbon tetrachlorid in doses of 4 to 30 cubic centimeters (3.75 to 8 fluid drams), in capsules or in 2 ounces of castor oil, has been found to remove all the hookworms from infested sheep. See remarks under "The nodular worm," page 44.

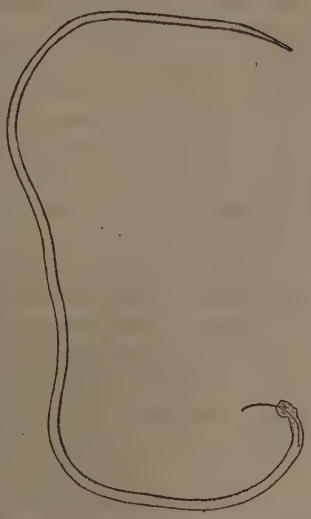

FIG. 29.—Thread-necked strongyle (*Nematodirus spathiger*). Male, greatly magnified. (From Ransom, 1911.)

Prevention.—Pasture-rotation methods, as outlined under the subject of stomach worms, will be found of great value in controlling sheep hookworms. Proper disposal of the manure, which carries the eggs of the worm, is also important. In view of the fact that this worm possibly enters the sheep through the skin of the legs as well as through the mouth while the animal is grazing, boggy land and loose, wet, sandy soil may be looked on with suspicion as apt to convey the infection by bringing the larvæ in contact with the skin in mud or wet sand.

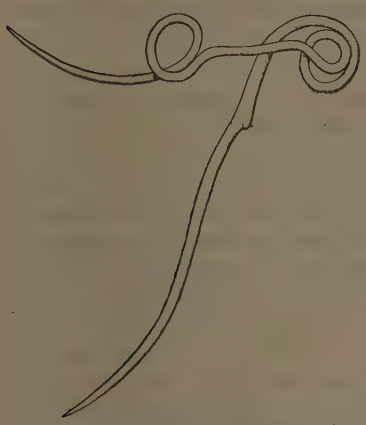

FIG. 30.—Thread-necked strongyle (*Nematodirus spathiger*). Female, greatly magnified. (From Ransom, 1911.)

THE THREAD-NECKED STRONGYLES.[20]

Location.—The thread-necked strongyles are found in the small intestine.

Appearance.—These are reddish worms, the anterior portion more slender than the posterior. The head and the neck end are transversely striated. In *N. spathiger* the male worm attains a length of 1.5 cm. ($\frac{3}{5}$ inch). The female attains a length of 2.3 cm. (about 1 inch).

Life history.—The eggs produced by the female worm pass out in the feces and an embryo develops in them. This worm molts twice in

[20] *Nematodirus filicollis, N. spathiger,* etc.

the shell, the skin that separates at the second molt, however, remaining on the larva. The larva hatches under the influence of alternate moistening and drying or of temperatures of 24° to 32° C. (75° to 90° F.). Like the stomach worm, the ensheathed larva then ascends blades of grass under favorable conditions of temperature and moisture, and is taken in by sheep as they feed. These larvæ are very resistant to cold and drying, and have also been found to live in water for over 11 months. In the intestine of the sheep the larvæ develop to adult worms.

Distribution.—At least one species of these worms (*N. spathiger*) appears to be quite common in sheep in the United States.

Symptoms and lesions.—When present in small numbers it is unlikely that these worms do much damage, but sheep infested with large numbers have been found to be unthrifty. So far the only symptoms that may be attributed to them are those commonly associated with gastrointestinal parasitism in general—those of malnutrition. No definite lesions have yet been described for this worm.

Treatment.—The treatment for infestation with this worm has not yet been worked out. Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 ounces of castor oil has been found very effective in a few cases in removing these worms and is the only drug which has been found of value. See remarks under "The nodular worm," page 42.

Prevention.—The same measures that are of value against stomach worms will probably be of value against the thread-necked worms.

THE WHIPWORM.[21]

Location.—The whipworm occurs in the large intestine, usually in the cecum, but rarely elsewhere in the digestive tract.

Appearance.—The body of this worm is thick posteriorly and very slender anteriorly, the anterior portion of the body being two or three times as long as the posterior portion, from which fact it receives the name of whipworm. The thick portion is comparable to a whip handle and the thin portion to a whiplash (fig. 31). The male is 5 to 8 cm. (2 inches to over 3 inches) long, with the anterior portion of the body three times as long as the posterior portion. The male spicule is 5 to 6 mm. long, and has a long sheath, covered with spines and terminating in a bulbous enlargement. The female is 5 to 7 cm. long, with the anterior portion of the body twice as long as the posterior portion. The eggs of the whipworms are characteristically lemon-shaped.

Life history.—So far as is known this worm has a simple life history. The eggs produced by the adult worm pass out in the feces

[21] *Trichuris ovis.*

and an embryo develops in each egg under suitable conditions of temperature and moisture. When these eggs are swallowed by sheep, the embryos develop to adult worms.

Distribution.—These worms are very common in sheep in the United States and many other countries.

Symptoms and lesions. — It has been found that whipworms in man set up a low-grade inflammation, with distinct symptoms of discomfort and distress. In animals, inflamed areas are quite commonly found where whipworms attach. The head end of the worm is usually found sewed into the mucosa, and, as the mouth is unarmed, it appears that the penetration of the mucosa is perhaps due to the digestive action of a substance secreted by the worm. There is likelihood of the lining of the intestine being infected by bacteria through the entrance of the worm, or of the burrow becoming infected subsequently. Though there are no well-defined clinical symptoms for whipworm infestation in sheep, it can not be doubted that the worms exert an injurious effect, more pronounced when the worms are numerous. On post-mortem examination the thick posterior ends of the worms will be found in the lumen of the intestine, the anterior ends being in the mucosa.

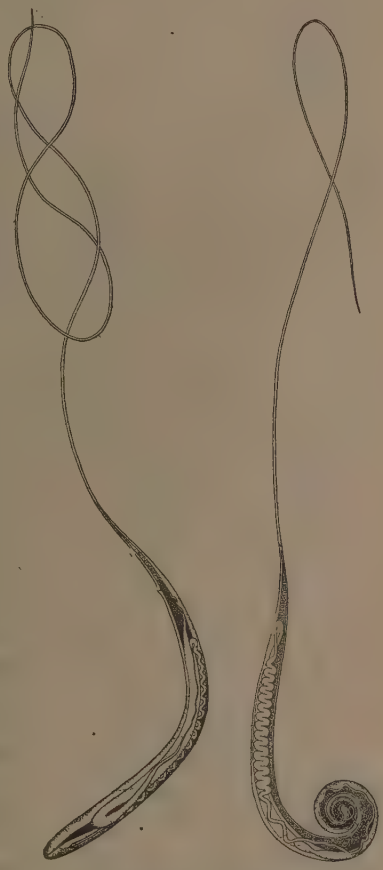

FIG. 31.—Whipworms (*Trichuris ovis*). Female at left; male at right. Magnified. (From Curtice, 1890.)

Treatment.—Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 ounces of castor oil has been found to remove 30 to 90 per cent of the whipworms from sheep in experimental tests. See remarks under "The nodular worm," page 42.

Prevention.—Prevention of whipworm in sheep is a matter of sanitation and pasture rotation. The same measures that are useful in controlling stomach worm will be found of value in controlling whipworm.

FIG. 32.—Thread lungworms (*Dictyocaulus filaria*). Male at right; female at left. Highly magnified. (From Curtice, 1890.)

THE THREAD LUNGWORM.[22]

Location.—The thread lungworm is found in the air passages, bronchi and bronchioles of the lungs.

Appearance.—These are rather long worms, easily observed. They are white and the intestine shows as a dark hair line throughout the length of the worm (fig. 32). The male is 3 to 8 cm. (from more than 1 inch to more than 3 inches) long. The female is 5 to 10 cm. (2 to 4 inches) long, with a straight, conical tail. The eggs contain an embryo when they leave the body of the mother worm.

Life history.—The eggs deposited by the female hatch in the lung of the host animal, probably in the course of 24 hours, and are expelled in coughing, or swallowed and passed in the feces. The newly hatched larva has a rounded head and a rather blunt tail. It molts twice in the course of the next few days, the time varying with temperature and moisture, and, under ordinary circumstances, is infective within 10 days. This larva then climbs up grass blades, when they are wet and the weather is warm, as does the larva of the stomach worm and thread-necked worm, and here it is taken in by grazing sheep and makes its way to the lungs. In the course of a month the sheep begin to show symptoms of lungworm, and in about five weeks embryos appear in the manure.

Distribution.—These worms are widely distributed over the world and are comparatively common in the United States, especially in the South and where there is plenty of moisture and warmth.

[22] *Dictyocaulus filaria.* Synonym, *Strongylus filaria.*

Symptoms and lesions.—The worms and their eggs and larvæ set up an irritation of the lung tissue at the point where they are located, causing inflammation and a catarrhal condition, the latter manifested in the production of a frothy mucus, sometimes containing traces of blood. Bacterial infection of the weakened lung tissue may follow, and the lungs may show pus and consolidated areas. Usually the latter conditions are not present. The symptom first noted is a husky cough, and if the invasion is extensive this may be followed by difficulty in breathing. If left alone some animals are likely to die of weakness or suffocation. The disease may be diagnosed from the clinical symptoms by an experienced veterinarian or stockman who is familiar with it; the diagnosis may be confirmed by a microscopic examination of the feces or of the saliva from the back of the tongue, though occasionally one may not find larvæ, especially in recent infections, in spite of the presence of worms in the lungs. On post-mortem the lungs show inflamed patches, and the worms can be found in the air passages.

Treatment.—Most of the treatments by intratracheal injections that have been used for lungworm disease of cattle are not very satisfactory and are rather dangerous to sheep. A treatment which has been used on a large number of animals with reports of satisfactory results consists in injecting chloroform in 3-mil doses (about three-fourths of a teaspoonful) into the nostrils of the sheep by means of a medicine dropper, the head of the sheep being tilted back. The nostrils of the sheep are then held with the fingers until the animal is somewhat groggy. This treatment may be repeated at intervals of three to five days, if necessary, for a total of not more than three doses. It is recommended that a dose of Epsom or Glauber's salt be given two hours after the treatment.

Nursing treatment appears to be the safest and most satisfactory treatment in most cases. Sheep should be taken off wet pasture and placed on high, dry pasture or put up and fed dry feed. A safe supply of drinking water and plenty of good feed are of value in tiding the sheep over the critical stages of the disease and allowing the worms to die out.

Prevention.—The same general rules that apply in the case of the stomach worm apply here. Sanitation and pasture rotation, isolation of infested animals, and special precautions in regard to the pasturing and watering of lambs and young animals are all measures of value.

THE HAIR LUNGWORM.[23]

Location.—These worms occur in the small bronchioles and in the lung tissue.

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[23] *Synthetocaulus rufescens.* Synonym, *Strongylus rufescens.*

Appearance.—Hair lungworms (figs. 33 and 34) are much smaller than the thread lungworms. The body has a characteristic brownish-red color, due to the color of the intestine. The male is 1.8 to 2.8 cm. (about two-thirds inch to a little more than 1 inch) long and terminates at the tail in a corneus arc, followed by the small bursa (fig. 33). The female is 2.5 to 3.5 cm. (1 to 1.4 inches) long, with a moderately pointed tail.

FIG. 33.—Hair lungworm (*Synthetocaulus rufescens*). Tail of male, viewed from side. Magnified. (From Railliet, 1893.)

Life history.—The life history of the hair lungworm has not yet been worked out, but it is probably similar to that of the thread lungworm.

Distribution.—The parasite is widely distributed and has been found to be fairly common in the United States. It is perhaps less common than the previous species or is possibly found less often because it is smaller.

Symptoms and lesions.—These worms occasion various forms of verminous pneumonia. The adult worms cause a lobular pneumonia; the eggs and larvæ cause a diffuse pneumonia, or when aggregated in the pneumonic areas may cause a pneumonia with areas resembling tubercles. These areas show as grayish-yellow tumors, which may attain a diameter ranging from a few millimeters to 2 centimeters (four-fifths of an inch). Careful post-mortem examination of these pneumonic areas will disclose the reddish worms, and the eggs and larvæ may be found by microscopic examination of such tissue. The weakened tissues afford lodging for disease-producing bacteria, sometimes leading to pus formation, in which case the evil effects are considerably increased. Sheep will survive an infection with worms which prevents only a small amount of lung tissue from functioning, but heavy infections reduce the amount of living tissue available for breathing to an extent that often proves fatal, and bacterial complications add to this and to the toxic material which is absorbed to the injury of the animal.

FIG. 34.—Hair lungworm (*Synthetocaulus rufescens*). Tail of female, viewed from side. Magnified. (From Curtice, 1890.)

Treatment.—We have little evidence in regard to a satisfactory treatment for this worm, but the nursing treatment given for the preceding species would probably be the best procedure.

Prevention.—The preventive measures outlined for the thread lungworm apply here.

OTHER INTERNAL PARASITES.

Various other kinds of roundworms besides those that have been mentioned infest sheep, and some of them at times prove very injurious. The methods of prevention recommended for stomach worms, hookworms, and others in this bulletin, will help to protect sheep also from these other roundworms. There are also certain species of flukes, tapeworms, protozoa, and arthropods, other than those discussed here, which are omitted because they are relatively less important, so far as we are aware at present.

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